8060A
Digital Multimeter

Instruction Manual

FLUKE®

8060A
Digital Multimeter

Instruction Manual

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John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206

Rev. 6/81

Table of Contents

SECTION	TITLE	PAGE
1	**INTRODUCTION AND SPECIFICATIONS**	**1-1**
	1-1. INTRODUCTION	1-1
	1-2. SPECIFICATIONS	1-2
	1-3. ITEMS FURNISHED WITH EQUIPMENT	1-2
2	**OPERATING INSTRUCTIONS**	**2-1**
	2-1. INTRODUCTION	2-1
	2-2. UNPACKING YOUR INSTRUMENT	2-1
	2-3. BATTERY INSTALLATION OR REPLACEMENT	2-1
	2-4. FUSE REPLACEMENT	2-3
	2-5. PHYSICAL FEATURES	2-3
	2-6. Front Panel	2-3
	2-7. Display	2-6
	2-8. SIGNAL INPUT LIMITS	2-6
	2-9. OPERATION	2-7
	2-10. Power-On Self Test	2-7
	2-11. AC/DC Voltage (V)	2-8
	2-16. AC/DC Current (A)	2-12
	2-17. Resistance (Ω)	2-14
	2-20. Conductance (S)	2-16
	2-21. Diode Test	2-18
	2-22. Relative (REL)	2-19
	2-23. Frequency (Hz)	2-21
	2-24. Decibel (dB)	2-23
	2-25. dBV	2-24
	2-26. Continuity ( )	2-25
	2-27. INITIAL CHECK-OUT PROCEDURE	2-25
3	**APPLICATIONS**	**3-1**
	3-1. INTRODUCTION	3-1
	3-2. DETERMINING AMPLIFIER BANDWIDTH	3-1
	3-3. USING THE 8060A AS A Q-METER	3-2

(continued on page ii)

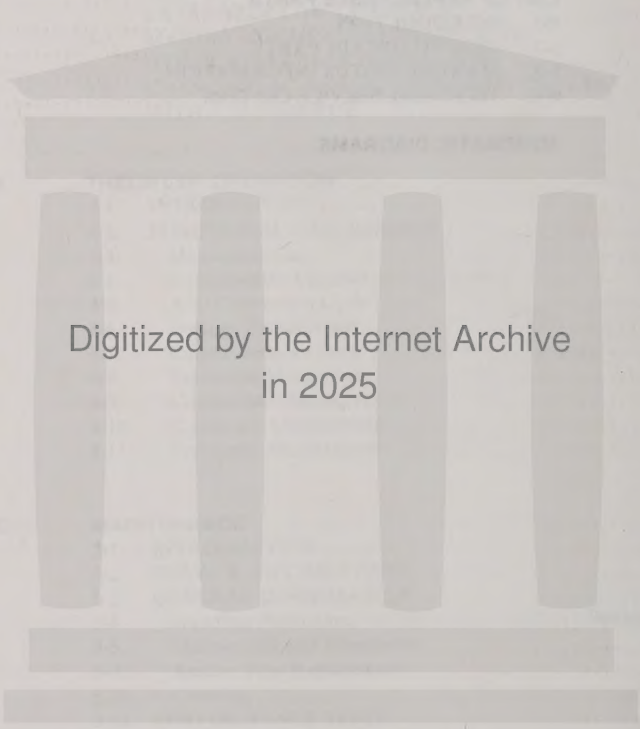
TABLE OF CONTENTS, *(continued)*

SECTION	TITLE	PAGE
	3-4. MEASURING AMPLIFIER STAGE GAIN WITH RELATIVE dB	3-2
	3-5. GENERAL AUDIO USES	3-4
	3-6. USING THE 8060A TO MEASURE EXTREMELY LOW CURRENTS	3-4
	3-7. MAKING dBm MEASUREMENTS WITH OTHER REFERENCE IMPEDANCES	3-4
	3-8. CHANGING AC dB REFERENCE IMPEDANCES WITH A DC SOURCE	3-6
4	**THEORY OF OPERATION**	**4-1**
	4-1. INTRODUCTION	4-1
	4-2. FUNCTIONAL DESCRIPTION	4-1
	4-3. Microcomputer	4-1
	4-4. Measurement Acquisition Chip (MAC)	4-3
	4-5. A/D Conversion Cycle	4-3
	4-6. Voltage Measurement	4-5
	4-7. Current Measurement	4-7
	4-8. Resistance Measurement	4-7
	4-9. Conductance Measurement	4-8
	4-10. Continuity Measurement	4-8
	4-11. Frequency Measurement	4-9
5	**MAINTENANCE**	**5-1**
	5-1. INTRODUCTION	5-1
	5-2. SERVICE INFORMATION	5-1
	5-3. GENERAL INFORMATION	5-2
	5-4. Handling Precautions for Using Static Sensitive Devices	5-2
	5-5. Disassembly and Reassembly	5-3
	5-9. Backup Fuse Replacement	5-8
	5-10. Cleaning	5-8
	5-11. PERFORMANCE TESTS	5-9
	5-12. Initial Procedure	5-9
	5-13. Microcomputer and Display Test	5-9
	5-14. Voltage Test	5-9
	5-15. Resistance Test	5-9
	5-16. Continuity Test	5-10
	5-17. Conductance Test	5-12
	5-18. Current Test	5-12
	5-19. Diode Test	5-13
	5-20. Frequency Test	5-13
	5-21. CALIBRATION ADJUSTMENTS	5-14
	5-22. TROUBLESHOOTING	5-15

(continued on page iii)

TABLE OF CONTENTS, *(continued)*

SECTION	TITLE	PAGE
	5-23. Self-Tests	5-16
	5-27. Troubleshooting Guide	5-17
6	**LIST OF REPLACEABLE PARTS**	**6-1**
	6-1. INTRODUCTION	6-1
	6-2. HOW TO OBTAIN PARTS	6-1
	6-3. MANUAL STATUS INFORMATION	6-2
	6-4. TECHNICAL SERVICE CENTERS	6-2
7	**SCHEMATIC DIAGRAMS**	**7-1**



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List of Tables

TABLE	TITLE	PAGE
1-1.	8060A Specifications	1-2
2-1.	Controls, Indicators and Connectors	2-4
2-2.	Input Overload Limits	2-7
2-3.	Resistance Function Autoranges and Resolution	2-15
2-4.	Frequency Function Autoranges and Resolution	2-22
2-5.	Sensitivity for the Frequency Function	2-22
2-6.	Maximum Input Voltages for the Frequency Function	2-23
3-1.	Equivalent Voltage Levels for Modifying the Reference Impedance	3-5
4-1.	Voltage Input Divider	4-6
5-1.	Required Test Equipment	5-2
5-2.	Voltage Test	5-11
5-3.	Resistance Test	5-11
5-4.	Current Test	5-13
5-5.	Frequency Test	5-13
5-6.	Switch Decoding Self-Test	5-17
5-7.	Troubleshooting Guide	5-18
5-8.	Troubleshooting the Resistance Function: Voltage Sources for Ranges	5-22
5-9.	U3 (MAC) Pin Descriptions	5-23
6-1.	8060A Final Assembly	6-3
6-2.	A1 Main PCB Assembly	6-7

List of Illustrations

FIGURE	TITLE	PAGE
Frontispiece	8060A True RMS Multimeter	*viii*
2-1.	Removal of Battery Compartment Cover	2-2
2-2.	Battery Removal and Fuses	2-2
2-3.	Controls, Indicators and Connectors	2-4
2-4.	8060A Display	2-6
2-5.	Overrange Indicator	2-6
2-6.	Voltage Operation	2-8
2-7.	AC and DC Waveform Components	2-9
2-8.	Multiplication Factors for Converting Waveforms	2-10
2-9.	High Impedance DC Voltage	2-11
2-10.	Current Operation	2-12
2-11.	Calculating Burden Voltage Error	2-13
2-12.	Resistance Operation	2-14
2-13.	Selection of Autoranging Kilohms	2-15
2-14.	Conductance Operation	2-16
2-15.	Conductance/Resistance Conversion	2-17
2-16.	Diode Test	2-18
2-17.	Relative (REL) Operation	2-19
2-18.	Frequency (Hz) Operation	2-21
2-19.	Decibel (dB) Operation	2-24
2-20.	Continuity (⇥) Operation	2-25
3-1.	Measuring Amplifier Bandwidth	3-2
3-2.	Measuring Q with the 8060A	3-3
3-3.	Measuring Stage Gain with Relative dB	3-3
4-1.	8060A Block Diagram	4-2
4-2.	Analog Portion of the A/D Converter	4-4
4-3.	A/D Measurement Cycle	4-4
4-4.	Voltage Measurement	4-6
4-5.	Current Measurement	4-7
4-6.	Resistance/Conductance/Continuity Measurement	4-8
4-7.	Frequency Measurement	4-9

(continued on page vii)

LIST OF ILLUSTRATIONS, *(continued)*

FIGURE	TITLE	PAGE
5-1.	Calibration and Backup Fuse (F2) Access	5-4
5-2.	Assembling/ Disassembling the Microcomputer PCB and LCD	5-6
5-3.	Disassembling the LCD	5-7
5-4.	General Equipment Connection	5-10
5-5.	Equipment Connection for Current Test	5-12
6-1.	8060A Final Assembly	6-5
6-2.	8060A A1 Main PCB Assembly	6-11

Model 8060A Digital Multimeter

Section 1
Introduction and Specifications

1-1. INTRODUCTION

Your John Fluke Model 8060A is a handheld, microcomputer-based 4-1/2 digit multimeter that is ideally suited for use in the field, laboratory, shop or home. The 8060A has all the features that have become accepted standards for quality handheld multimeters, as well as some new features that have not been offered before in a handheld multimeter. New features include the following:

- True rms measurements for ac signals up to 100 kHz.
- Frequency measurements up to 200 kHz.
- Voltage measurements in dBm referenced to 600Ω or in dB relative to an operator-selected reference voltage.
- Resistance measurements up to 300 MΩ.
- Ability to store any input signal as an offset or relative reference value.

Other features include:

- FUNCTIONS:

  All standard DMM measurement functions, such as ac and dc volts and ac and dc current, as well as resistance, conductance, continuity, and diode test.

- RANGES:

  Leading zero suppression.

  Automatic polarity.

  Overrange indication.

  Protection from overloads and transients up to 6 kV.

  Dual-slope integration a/d conversion to ensure noise-free measurements.

Autoranging MΩ resistance range (to 300 MΩ), as well as four fixed resistance ranges from 200Ω to 200 kΩ.

- OPERATOR CONVENIENCE:

  4-1/2 digit Liquid Crystal Display.

  Software-controlled self-test routines for quick verification of internal circuitry and operation.

- POWER:

  170 hours of continuous operation can be expected from a 9V alkaline battery (NEDA 1604).

  Low battery voltage is automatically detected and displayed. The low battery indication, BT, appears on the display when about 20% of the battery life remains.

  Ordinary line operation is possible using a Fluke Model A81 Battery Eliminator.

A full line of accessories is available to enhance the capabilities of the 8060A.

1-2. SPECIFICATIONS

The specifications for the 8060A are listed in Table 1-1.

1-3. ITEMS FURNISHED WITH EQUIPMENT

Items shipped with your Digital Multimeter are as follows:

- Battery
- DMM Accessory List
- Instruction Manual
- Operator Guide Card
- Registration Form
- Statement of Calibration
- Test Leads

Table 1-1. 8060A Specifications

ELECTRICAL

The following specifications are based on a one-year calibration cycle, an operating temperature of 18 to 28°C (64 to 82°F) and a relative humidity not exceeding 80%.

DC Voltage

RANGE	RESOLUTION	ACCURACY ±(% of reading + no. of digits)
200 mV 2 V	01 mV .1 mV	0.04% + 2
20 V 200 V 1000 V	1 mV 10 mV 100 mV	0.05% + 2

RESPONSE TIME ..... 1 second maximum, to rated accuracy within selected range.

INPUT IMPEDANCE ..... 10 MΩ nominal

NORMAL MODE NOISE REJECTION ..... >60 db at 50 Hz or 60 Hz

COMMON MODE NOISE REJECTION ..... >120 dB at dc, >90 dB at 50 Hz and 60 Hz (1 kΩ imbalance).

OVERLOAD PROTECTION ..... 1000V dc or peak ac continuous, except 20 seconds maximum on 200 mV and 2V ranges above 300V dc or rms.

DC Voltage, High Impedance Mode

All specifications are the same as for the dc voltage mode except the following (only 200 mV and 2V ranges are available):

RANGE	RESOLUTION	ACCURACY ±(% of reading + no. of digits)
200 mV 2V	.01 mV .1 mV	0.05% + 2

INPUT IMPEDANCE ..... >1,000 MΩ, typically 10,000 MΩ

OVERLOAD PROTECTION ..... 300V dc or rms continuous, 20 seconds maximum 300V to 1000V dc or peak ac.

Table 1-1. 8060A Specifications (cont)

DC Voltage, dB Mode

Measurements are made in dBm referenced to 600Ω or relative dB. All specifications are the same as for dc voltage except the following:

DYNAMIC RANGE ..... With full .01 dB resolution, 99.79 dB. Total specified dynamic range is 136.22 dB (160 μV to 1000V).

RESOLUTION AND ACCURACY ..... Depends on linear dc count (count refers to the display in dc volts independent of the decimal points - see table below).

ACCURACY		
dBm Ref. 600Ω	Range	Tolerance
-74 to -56 (160 μV to 1.27 mV)	200 mV	±1 dB
-55.6 to -37.6 (1.28 mV to 10.23 mV)	200 mV	±.2 dB
-37.58 to -31.77 (10.24 mV to 19.99 mV)	200 mV	±.04 dB
-31.76 to -11.76 (20 mV to -199.99 mV)	200 mV	±.04 dB
-11.76 to 8.24 (.2V to 1.9999V)	2V	±.04 dB
8.24 to 28.24 (2.000V to 19.999V)	20V	±.04 dB
28.24 to 48.24 (20.00V to 199.99V)	200V	±.04 dB
48.24 to 62.22 (200.0 to 1000V	1000V	±.04 dB

LINEAR COUNTS	RESOLUTION	ACCURACY
19,999 to 1024	.01 dB	±.04 dB
1023 to 128	.1 dB	±.2 dB
127 to 16	1 dB	± 1 dB

Table 1-1. 8060A Specifications (cont)

AC Voltage (True RMS, AC-Coupled)

RANGES ..... 200 mV, 2V, 20V, 200V, 750V

ACCURACY ..... ±(% of reading + no. of digits). See table below:

INPUT VOLTAGE	RESOLUTION	RANGE	20 Hz to 45 Hz	45 Hz to 1 kHz	1 kHz to 10 kHz	10 kHz to 30 kHz	30 kHz to 50 kHz	50 kHz to 100 kHz
10.0 to 199.99 mV	.01 mV	200 mV	1% +10	0.2% +10	0.2% +20	0.5% +40	1% +100	3% +200
.1000 to 1.9999V	.1 mV	2V		0.5% +10	0.5% +20	1% +40	2% +100	
1.000 to 19.999V	1 mV	20V						
10.00 to 199.99V	10 mV	200V						
100.0 to 499.9V	100 mV	750V	Not Specified		Not Specified			
500.0 to 750.0V				1% +10				

AC Voltage (cont.)

INPUT IMPEDANCE ..... 10 MΩ shunted by <100 pF

COMMON MODE NOISE REJECTION ..... >60 dB at 50 Hz and 60 Hz (1 kΩ imbalance)

CREST FACTOR RANGE . 1:1 to 3:1

RESPONSE TIME ..... Five seconds maximum to rated accuracy within selected range, 12 seconds to rated accuracy from an overload.

OVERLOAD PROTECTION ..... 750V rms or 1000V peak continuous except 20 seconds maximum on the 200 mV range above 300V rms or 300V dc. Input not to exceed a volt-hertz product of 10^7 (for example, 200V at 50 kHz).

Table 1-1. 8060A Specifications (cont)

AC Voltage, dB Mode (True RMS, AC-Coupled)

Measurements are made in dBm referenced to 600Ω or relative dB. All specifications are the same as for ac voltage except the following:

DYNAMIC RANGE ..... With full .01 dB resolution, 97.30 dBm. Total specified dynamic range is 109.72 dBm (2.45 mV to 750.0V ac rms).

RESOLUTION ..... Depends on number of linear ac counts (count refers to the actual number on the display independent of the decimal point. See table below).

LINEAR COUNTS*	RESOLUTION
19,999 to 1024 1023 to 128 127 to 16	.01 dB .1 dB 1 dB

*Not specified below 245 counts.

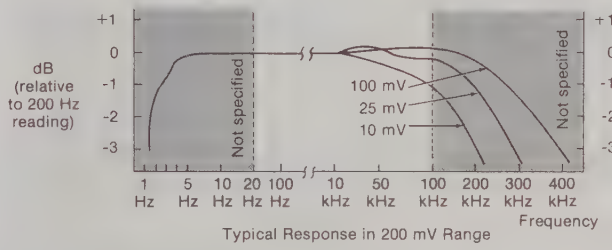
ACCURACY ..... See table below:

dBm REF. 600Ω	RANGE	20 Hz to 45 Hz	45 Hz to 10 kHz	10 kHz to 30 kHz	30 kHz to 50 kHz	50 kHz to 100 kHz
-50.0 to -37.6 (2.45 mV to 10.23 mV)	200 mV	0.5 dB	1.0 dB	3.0 dB	Not Specified	
-37.58 to -31.76 (10.24 mV to 20.00 mV)	200 mV	0.20 dB		0.50 dB	1.00 dB	2.20 dB
-31.76 to -11.76 (20 mV to 199.99 mV)	200 mV	0.10 dB* 0.15 dB 1 kHz		0.15 dB* 0.30 dB	0.30 dB* 0.65 dB	0.50 dB* 1.20 dB
-11.76 to 8.24 (.2000V to 1.9999V)	2V					
8.24 to 28.24 (2.000V to 19.999V)	20V					
28.24 to 48.24 (20.00V to 199.99V)	200V					
48.24 to 59.72 (200.0V to 750.0V	750V	0.5 dB		Not Specified		

*Specification applies above 8000 linear counts.

Table 1-1. 8060A Specifications (cont)

AC Voltage, dB Mode (cont.)

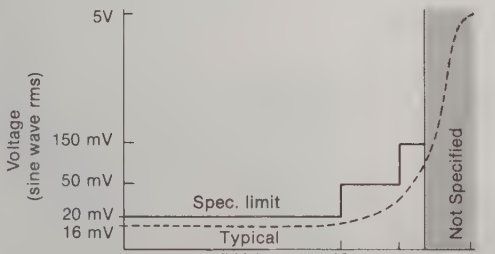


Typical Response in 200 mV Range

Frequency

FREQUENCY RANGE (Fully Autoranging)	RESOLUTION	ACCURACY ±(% of reading + no. of digits)
200 Hz	.01 Hz	.05% + 1
2000 Hz	.1 Hz	
20 kHz	1 Hz	
200 kHz	10 Hz	

INPUT SIGNAL	SENSITIVITY (based on sine wave V rms)
12 Hz to 20 kHz	20 mV or 10% of voltage range*
20 kHz to 100 kHz	50 mV or 25% of voltage range*
100 kHz to 200 kHz	150 mV or 75% of voltage range*
*Whichever value is greater	



Frequency Input Sensitivity (200 mV range)

Table 1-1. 8060A Specifications (cont)

Frequency (cont.)

AC VOLTAGE RANGE	MAXIMUM USEABLE AC VOLTAGE*
200 MV	±5V peak
2V	±50V peak
20V	±500V peak
200V	±1000V peak
750	±1000V peak

*Signal not to exceed a volt-hertz product of 1×10^7.

INPUT CHARACTERISTICS ..... AC-coupled, 10 MΩ shunted by <100 pF

OVERLOAD PROTECTION . 759V rms or 1000V peak continuous except 20 seconds maximum on the 200 mV range above 300V rms or 300V dc. Input not to exceed a volt-hertz product of 10^7 (for example, 200V at 50 kHz).

EXTENDED FREQUENCY

Selection ..... Enabled by holding down Hz button at power on.

Range ..... 12 Hz to 700 kHz, typically.

Resolution ..... 100 Hz above 200 kHz.

Accuracy ..... ±(.05% of reading + 2 digits)

Sensitivity (sine wave V rms) ..... Typically 100 mV at 200 kHz increasing to 4.5V at 700 kHz in the 200 mV range. Will measure a TTL signal (50% duty cycle) to 420 kHz, typically.

Resistance

RANGES ..... 200Ω, 2 kΩ, 20 kΩ, 200 kΩ, autoranging MΩ. The MΩ range extends from .0001 MΩ to 300 MΩ in three autoranged ranges. Upscale range changes are made at 2 MΩ and 20 MΩ. Downscale range changes are made at 19 MΩ and 1.9 MΩ.

ACCURACY ..... ±(% of reading + no. of digits). See table below.

Table 1-1. 8060A Specifications (cont)

Resistance (cont.)

RANGE		RESOLUTION	ACCURACY	FULL-SCALE VOLTAGE	MAX CURRENT	OPEN CIRCUIT VOLTAGE
200Ω		0.01Ω	(0.07%+2+.02Ω)	<250 mV	<1.1 mA	<4.8V
2 kΩ		0.1Ω	(0.07%+2)		<150 μA	<1.5V
20 kΩ		1Ω	(0.07%+2)		<15 μA	
200 kΩ		10Ω	(0.07%+2)		<1.5 μA	
MΩ	0-1.9999 MΩ	100Ω	(0.15%+2)	<2.5V	<2.5 μA	<2.5V
	2-19.99 MΩ	10 kΩ	(0.2%+3)			
	20-99.9MΩ	100 kΩ	(1%+3)			
	100-300MΩ	1 MΩ	(2%+3)			
AUTORANGING KΩ		0.1Ω TO 1 kΩ	(0.2%+5)		<1.0 mA	

RESPONSE TIME ..... Two seconds maximum to rated accuracy for all ranges except MΩ. For MΩ, 8 seconds maximum.

OVERLOAD PROTECTION ..... 500V dc or rms ac for all ranges.

Conductance

RANGE ..... 2000 nS (equivalent to a resistance range from 500 kΩ to 10,000 MΩ)

RESOLUTION ..... 0.1 nS

ACCURACY ..... ±(0.5% of reading + 20 digits)

OPEN CIRCUIT VOLTAGE ..... <1.5V

OVERLOAD PROTECTION ..... 500V dc or rms ac

Table 1-1. 8060A Specifications (cont)

Continuity

RANGES ..... All resistance ranges

THRESHOLD ..... Nominally 10% of range (for example, 20Ω in the 200Ω range) for 200Ω, 2 kΩ, 20 kΩ, 200 kΩ ranges. Nominally 20 kΩ in MΩ range.

DISPLAY INDICATION ... Horizontal bar across the top of the display and/or 2.667 kHz tone. Indication is present for a minimum of 200 ms.

RESPONSE TIME ..... 50 μs maximum (10 μs typical)

OVERLOAD PROTECTION ..... 500V dc or rms ac

Diode Test

RANGE 2V

TEST CURRENT ..... 1 mA (±10%) Typical

ACCURACY ..... ±(0.05% of reading + 2 digits)

RESPONSE TIME ..... 2 seconds maximum

OVERLOAD PROTECTION ..... 500V dc or rms ac

DC Current

RANGE	RESOLUTION	ACCURACY ±(% of reading + no. of digits)	BURDEN VOLTAGE
200 μA	.01 μA	0.2% + 2	.3V typical
2 mA	.1 μA		.3V typical
20 mA	1 μA	0.3% + 2	.3V typical
200 mA	10 μA		.3V typical
2000 mA	100 μA		.9V typical

OVERLOAD PROTECTION ..... 2A/250V fuse (operator replaceable) in series with 3A/600V fuse (service personnel replaceable).

AC Current (True RMS Responding, AC-Coupled

ACCURACY ..... ±(% of reading + no. of digits). See table below:

Table 1-1. 8060A Specifications (cont)

AC Current (cont.)

INPUT CURRENT	RESOLUTION	RANGE	20 Hz to 45 Hz	45 Hz to 3 kHz	3 kHz to 10 kHz	10 kHz to 30 kHz
10 to 199.99 μA	0.01 μ	200 μA	1%+10	0.75%+10	2%+20	2%+40
.1 to 1.9999 mA	0.1 μA	2 mA				
1 to 19.999 mA	1 μA	20 mA				
10 to 199.99 mA	10μA	200 mA				
100 to 1999.9 mA	100 μA	2000 mA			Not Specified	

BURDEN VOLTAGE ..... 0.3V rms typical except 2000 mA range, 0.9V rms typical.

OVERLOAD PROTECTION ..... 2A/250V fuse (operator replaceable) in series with 3A/600V fuse (service personnel replaceable).

Relative

SELECTION ..... When the REL button is pushed, the input applied at that time is stored as a zero reference point. Subsequent readings indicate deviations (±) from the reference point.

ACCURACY ..... Error does not exceed the sum of the errors of the reference reading and the subsequent reading.

GENERAL

Maximum Common Mode Voltage ..... 500V dc or ac rms

Display Update Rate ..... 2.5 readings/second for all functions except frequency and dB. For frequency, 1 reading/second. For dB, 1.4 readings/second.

Table 1-1. 8060A Specifications (cont)

GENERAL (cont.)	
Display	4½ digit duplex LCD (19,999 count), leading zero suppression, autopolarity.
Display Annunciators	BT (low battery indicator), Hz or kHz (frequency unit), dB (dB function enabled), REL (relative function enabled). ⊣◆⊢ and ıllı (continuity function enabled), and ▬▬ (bar indicates continuity detected).
A/D Converter	Dual-slope converter
Power	Single standard 9V battery (NEDA 1604), or Fluke A-81 Battery Eliminator option available for 100, 115, or 230V ac operation.
Battery Life	Typically 170 hours with an alkaline battery. BT appears on display when approximately 20% of battery life remains.
Size	180 mm L x 86 mm W x 45 mm H (7.1" L x 3.4" W x 1.8" H)
Weight	.41 kg (14.5 oz.)
Shock and Vibration	MIL-T-28800B
ENVIRONMENTAL	
Operating Temperature	0 to 50°C
Storage Temperature	-35 to +60°C
Accuracy Temperature Coefficient	0.1 x the applicable accuracy specification per °C (plus the initial 23°C specification) for 0 to 18°C and 28 to 50°C.
Relative Humidity	0 to 80% R.H. from 0 to +35°C, 0 to 70% from +35°C to +50°C, except 0 to 70% R.H. for MΩ range above 20 MΩ.

Section 2
Operating Instructions

2-1. INTRODUCTION

This section describes how to make measurements with your 8060A. Even though you may have used a multimeter before, we suggest that you take the time to read this material carefully so that you can take full advantage of the wide variety of measurement functions offered by the 8060A.

2-2. UNPACKING YOUR INSTRUMENT

Your instrument was shipped with two test leads (one red and one black), a 9V battery, and this manual. Check the shipment carefully and immediately contact the place of purchase if anything is missing or damaged in shipment.

If reshipment is necessary, please use the original shipping container. If the original container is not available, be sure that adequate protection is provided to prevent damage during shipment. It is recommended that the instrument be surrounded by at least three inches of shock-absorbing material in the shipping container.

2-3. BATTERY INSTALLATION OR REPLACEMENT

The 8060A is designed to operate on a single, common, inexpensive 9V battery (NEDA 1604). When you receive the instrument, the battery will not be installed. Once the battery is installed, you can expect a typical operating life of up to 170 hours with an alkaline battery, or 80 hours with a carbon-zinc battery. When the battery has exhausted about 80% of its useful life the BT indicator will appear at the far left of the display. Your instrument will continue to operate properly for at least 24 hours with an alkaline battery after BT first appears on the display. The 8060A also may be operated from a standard ac power line outlet when used with the optional A81 Battery Eliminator (refer to Section 7 for a description). Use the following procedure to install or replace the battery:

WARNING

TO AVOID ELECTRICAL SHOCK, TURN OFF THE INSTRUMENT AND REMOVE THE TEST LEADS AND ANY INPUT SIGNALS BEFORE REPLACING THE BATTERY.

1. Set the 8060A power switch to OFF.

2. Remove test leads from external connections and from the 8060A input terminals.

3. Turn the instrument over and use your thumbs to pry off the battery cover as shown in Figure 2-1.

4. Slide the battery out of the compartment as shown in Figure 2-2.

5. Carefully pull the battery clip free from the battery terminals (if replacing the battery) and attach the new battery.

6. Slide the battery and its leads into the compartment and slide the cover into place.

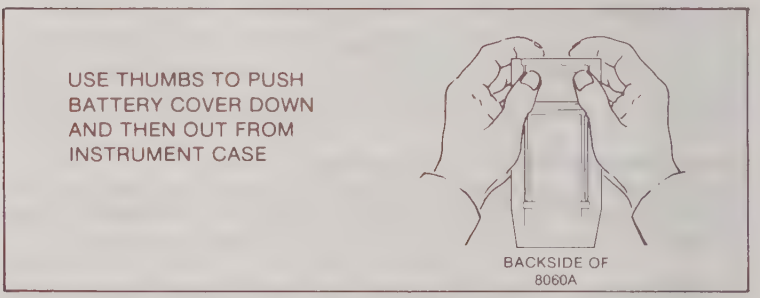


Figure 2-1. Removal of Battery Compartment Cover

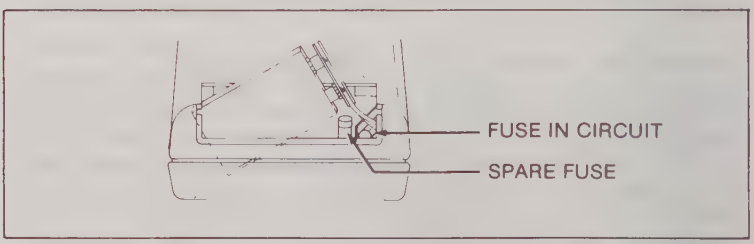


Figure 2-2. Battery Removal and Fuses

You can measure the voltage of your battery by using the following procedure:

1. Select the dc voltage function and the 20V range (refer ahead to Figure 2-6 if necessary).

2. Locate the opening for the battery eliminator jack on the right side of the instrument to the right of the display. Touch the red (VΩS) probe tip

to the side contact (not the center pin). Be sure you do not short the battery by shorting the side contact to the center pin. Battery voltage should be between 5.2V to 10V for proper operation. If the voltage is less, the battery should be replaced.

2-4. FUSE REPLACEMENT

When you installed the battery, you probably noticed two fuses at the right side of the battery compartment (refer to Figure 2-2 or examine your instrument). The fuse at the far right is F1. Fuse F1, 2A/250V, protects the current input from an input overload. The other fuse is a spare fuse for F1. When you purchase your instrument, F1 should be installed and the spare fuse should be in one of the two slots next to it. The larger slot is for the American-style fuse, and the smaller slot is for the European-style fuse (either style fuse fits in the installation compartment).

If you need to replace F1, use the tip of a test lead to push the fuse forward from the end and then up to relase. Replace F1 with the appropriate 2A/250V fuse; American-style: fast-acting, type AGX2, 1/4 x 1″, John Fluke 376582; European-style: 5 x 20 mm, John Fluke 460972.

There is another fuse, F2, 3A/600V, which also protects the current input. The instrument cover must be removed to replace F2. This procedure is described in Section 5 and should only be done by a person qualified to service the instrument.

The following steps provide a quick and easy way to ckeck the condition of both fuses F1 and F2:

1. Select the resistance function and the 2 kΩ range (look ahead to Figure 2-12 if necessary).

2. Touch the red test lead tip to the A input jack so that the VΩS input and the A input are shorted together.

3. If the display reads .1000 ± .0100 kΩ, both fuses are good.

4. If the display reads OL, one or both fuses needreplacement.

2-5. PHYSICAL FEATURES

Before you begin using your 8060A, we suggest you take a few minutes to familiarize yourself with the instrument. All of the externally accessible features are shown in Figure 2-3 and described in Table 2-1. The front panel and the display are also described in the following paragraphs.

2-6. Front Panel

The front panel of the 8060A is designed to make function and range selection easy. The symbols and colors on the panel indicate which switches to push or buttons to press to select the function you want. Details are provided later with the description of each function.

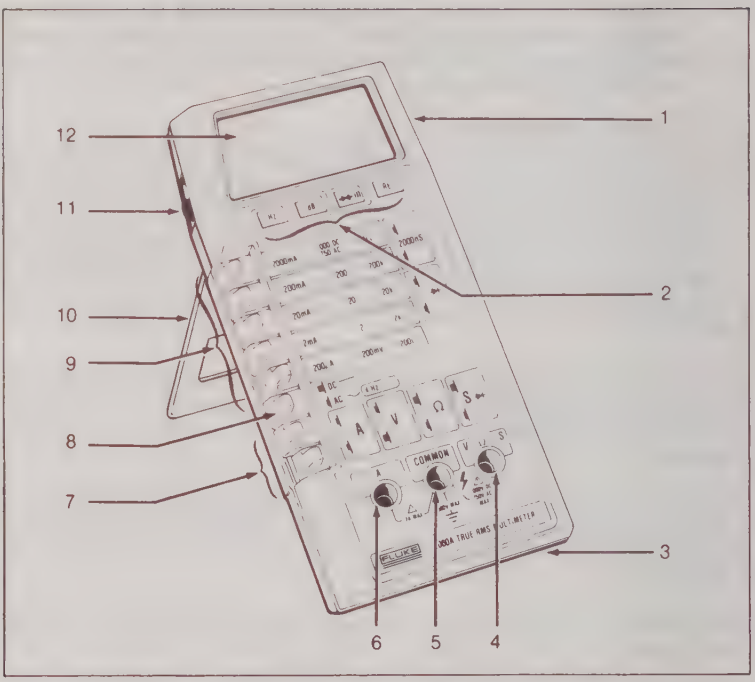


Figure 2-3. Controls, Indicators and Connectors

Table 2-1. Controls, Indicators and Connectors

ITEM NO.	NAME	FUNCTION
1	Battery Eliminator Connector	External input power connector for use with the A81 Battery Eliminator accessory.
2	Function Buttons: Hz, dB, ⊷ ·ıı·, REL	Push buttons that toggle on or toggle off the 'secondary' functions: frequency, dB, visible or audible continuity, or relative. These functions are selected in conjunction with the primary measurement functions (see items 7 and 8).
3	Battery Compartment and Cover	Cover for the 9V battery and the current fuse F1.

Table 2-1. Controls, Indicators and Connectors (cont)

ITEM NO.	NAME	FUNCTION
4	V Ω S Input Connector	Protected test lead connector used as the high input for all voltage, conductance, resistance, continuity, frequency measurements and diode test. All test lead connectors accept standard or safety-designed banana plugs.
5	COMMON Input Connector	Protected test lead connector used as the low or common input for all measurements.
6	A Input Connector	Protected test lead connector used as the high input for current measurements.
7	Function Switches: A,V,Ω,S ⊣◀	Interlocked switches that are used in conjunction with the input connectors to select the measurement functions. Pushing one switch releases the other, or both may be pushed together.
8	AC/DC Function Switch	Push-on/push-off switch is used to select ac or dc for current or voltage measurements. (Does not affect selection of diode test, resistance, or conductance functions).
9	Range Switches	Interlocked switches that are used to select ranges. Pushing a switch selects the corresponding range and releases other switch depressions. Also used to select conductance and the diode test.
10	Tilt Bail	A fold-out stand. The bail may also be removed (press in one of the legs at the hinge of the bail) and reinserted from the top as a hook for hanging the instrument.
11	Power Switch	Slide switch for turning instrument on or off.
12	Display	4½ digit LCD display (19999 maximum) with decimal point, minus sign, overrange, Hz, dB, continuity and relative indicators.

2-7. Display

The 8060A provides measurement results on the 4-1/2 digit LCD display (refer to Figure 2-4 or your instrument). The decimal point is placed automatically. Symbols in the upper portion of the display indicate when one of the secondary functions is enabled. The unit for the autoranging frequency measurements is displayed automatically as Hz or kHz. The units for all the other measurements are indicated by the range switch that is pushed in. Leading zeroes are not displayed.

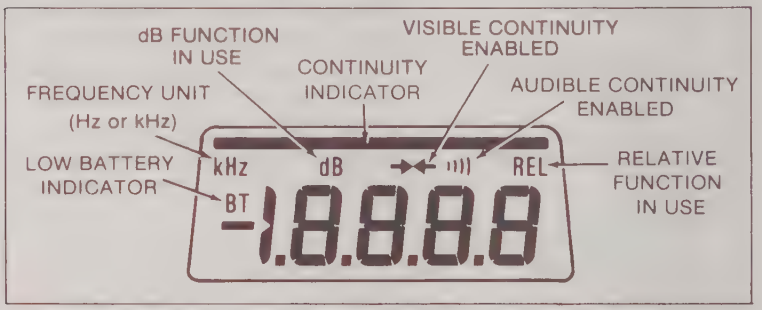


Figure 2-4. 8060A Display

If you are taking a measurement and the OL symbol appears on the display (Figure 2-5), an overrange condition is indicated, meaning that the input is higher than the range selected. You should select a higher range for the measurement. The OL symbol does not necessarily mean that the instrument is being exposed to a damaging input condition. For example, when measuring resistance, an open input will cause OL to appear.

Figure 2-5. Overrange Indicator

2-8. SIGNAL INPUT LIMITS

CAUTION

Exceeding the maximum input overload limits can damage your instrument.

Before you begin to use your 8060A, it is important to note the maximum inputs that may be applied to the instrument. Table 2-2 presents the maximum inputs that are allowed for each function, range, and input terminal.

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, DO NOT CONNECT THE COMMON INPUT TERMINAL TO ANY SOURCE MORE THAN 500 VOLTS DC OR RMS AC ABOVE EARTH GROUND.

Table 2-2. Input Overload Limits

FUNCTION	INPUT TERMINALS	MAXIMUM INPUT LIMIT
AC Voltage, AC dB, Frequency	VΩS and COMMON	750V rms or 1000V peak continuous except 20 seconds maximum on the 200 mV range above 300V dc or ac rms.
DC Voltage, DC dB	VΩS and COMMON	1000V dc or peak ac continuous except 20 seconds maximum on the 200 mV and 2V ranges above 300V dc or ac rms.
AC or DC Current	A and COMMON	2A maximum, fuse protected to 600V dc or ac rms.
Resistance, Conductance, Diode Test, and Continuity	VΩS and COMMON	500V dc or ac rms

2-9. OPERATION

The following paragraphs describe the power-on self-test, and how to operate your 8060A in each of the seven primary functions or the four secondary functions.

2-10. Power-On Self-Test

To turn on your instrument, locate the green switch on the left side of the instrument and slide it forward. Whenever you turn on the instrument, the 8060A automatically performs a self-test to make sure the display and the microcomputer are functioning properly. If everything is functioning properly, all the LCD segments in the display will turn on (Figure 2-4). After about one or two seconds, the display will go blank briefly before responding to switch selections.

If the LCD segments do not all turn on during the self-test, or if the instrument does not clear the display after the test and then respond to switch selections, something is probably wrong with the instrument. Try the test again, and if it fails, have a qualified person refer to Section 5. If there is no display when you turn on the instrument, check the battery and battery connections. You will find that if you turn off your instrument and then immediately turn it back on, a random assortment of LCD segments may be displayed. This is normal. After about a second the instrument should turn on all the LCD segments as usual during the self-test.

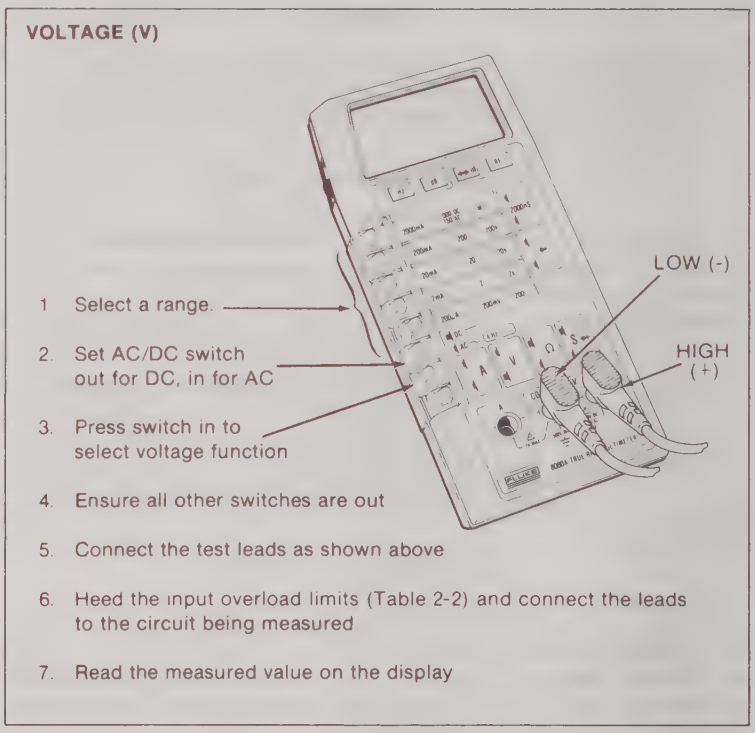

VOLTAGE (V)
LOW (-)
HIGH (+)
1 Select a range.
2. Set AC/DC switch out for DC, in for AC
3. Press switch in to select voltage function
4. Ensure all other switches are out
5. Connect the test leads as shown above
6. Heed the input overload limits (Table 2-2) and connect the leads to the circuit being measured
7. Read the measured value on the display

Figure 2-6. Voltage Operation

2-11. AC/DC Voltage (V)

Selection of the ac or dc voltage (V) functions is described in Figure 2-6. The 8060A offers five ac and five dc voltage ranges: 200mV, 2V, 20V, 200V, and 750V ac/ 1000V dc. All ranges present a 10 MΩ input impedance, which is shunted by <100pF in ac voltage measurements.

2-12. TRUE RMS MEASUREMENT

One of the most useful features of the 8060A is the direct measurement of true rms or effective ac voltages and ac currents. Mathematically, rms is defined as the square root of the sum of the squares of the ac and dc components. In physical terms, rms is equivalent to the dc value that dissipates the same amount of heat in a resistor as the original waveform. The reason that rms is so valuable is that it greatly simplifies the analysis of complex ac signals. Since rms is the dc equivalent to the original waveform, it can be used in the relationships derived from Ohm's law (E = I x R), and it provides a reliable basis for comparing dissimilar waveforms.

Most meters in use today have average-responding ac converters rather than true rms ac converters like the 8060A. Usually the gain in average-responding meters is adjusted so that the reading gives the rms value, provided the input signal is a harmonic-free sinusoid. However, if the signal is not sinusoidal, the average-responding meter does not give correct rms readings.

The 8060A ac converter actually calculates the rms value through analog computation. This means that 8060A readings are accurate rms values not only for harmonic-free sinusoids, but also for mixed frequencies, modulated signals, square waves, sawtooths, 10%-duty-cycle rectangular pulses, etc.

2-13. AC-COUPLED AC MEASUREMENTS

Input signals are ac-coupled in the ac functions. One of the major advantages of ac-coupling is that ripple measurements can be made on power supplies, phone lines, etc. Ripple measurements cannot be made with dc-coupling. Remember, however, that when the 8060A measures signals with the ac voltage function, the reading on the display does not include the dc component (if it exists). For example, consider the waveform in Figure 2-7. The ac voltage function will measure the ac rms component. The dc voltage function will measure the dc component. To obtain the total rms value for such a waveform, first measure the ac and dc values separately, then calculate the total rms value using the formula given in Figure 2-7.

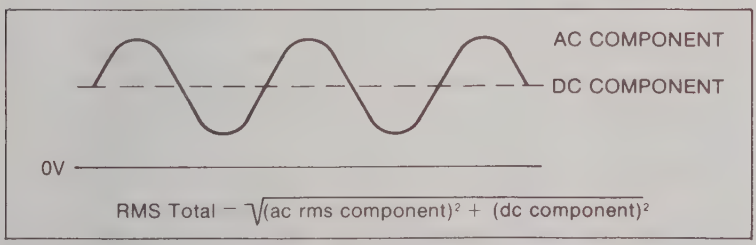
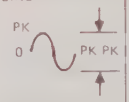
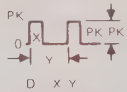


Figure 2-7. AC and DC Waveform Components

2-14. WAVEFORM COMPARISON AND CONVERSION

Figure 2-8 shows the relationship between common waveforms and the display readings for the 8060A and average-responding meters. Figure 2-8 also illustrates the relationship between ac and dc measurements for ac-coupled meters. For example, consider the first waveform, a 1.414V (0-pk) sinewave. Both the 8060A and the rms-calibrated average-responding meter display the correct rms reading of 1.000V (the dc component equals 0). However, consider the 1.414V (0-pk) rectified square wave. Both types of meters correctly measure the dc component (0.707V). But only the 8060A correctly measures the ac component (0.707V). The average-responding meter measures 0.785V, which amounts to a 5.6% error in the total rms measurement calculated from the ac and dc components.

AC COUPLED INPUT WAVEFORM	PEAK VOLTAGES		DISPLAY READINGS			DC AND AC TOTAL RMS
			AC COMPONENT ONLY		DC COMPONENT ONLY	TRUE RMS $\sqrt{ac^2 + dc^2}$
	PK PK	0-PK	RMS CAL*	8060A		
SINE 	2.828	1.414	1.000	1.000	0.000	1.000
RECTIFIED SINE (FULL WAVE)	1.414	1.414	0.421	0.435	0.900	1.000
RECTIFIED SINE (HALF WAVE)	2.000	2.000	0.764	0.771	0.636	1.000
SQUARE	2.000	1.000	1.110	1.000	0.000	1.000
RECTIFIED SQUARE	1.414	1.414	0.785	0.707	0.707	1.000
RECTANGULAR PULSE  D X Y K $\sqrt{D}$ $\overline{D^2}$	2.000	2.000	2.22K	2K	2D	$2\sqrt{D}$
TRIANGLE SAWTOOTH	3.464	1.732	0.960	1.000	0.000	1.000

RMS CAL IS THE DISPLAYED VALUE FOR AVERAGE RESPONDING METERS THAT ARE CALIBRATED TO DISPLAY RMS FOR SINE WAVES

Figure 2-8. Multiplication Factors for Converting Waveforms

Since average-responding meters have been in use for so long, you may have accumulated test or reference data based on them. The conversion factors in Figure 2-8 should help you convert between the two measurement methods.

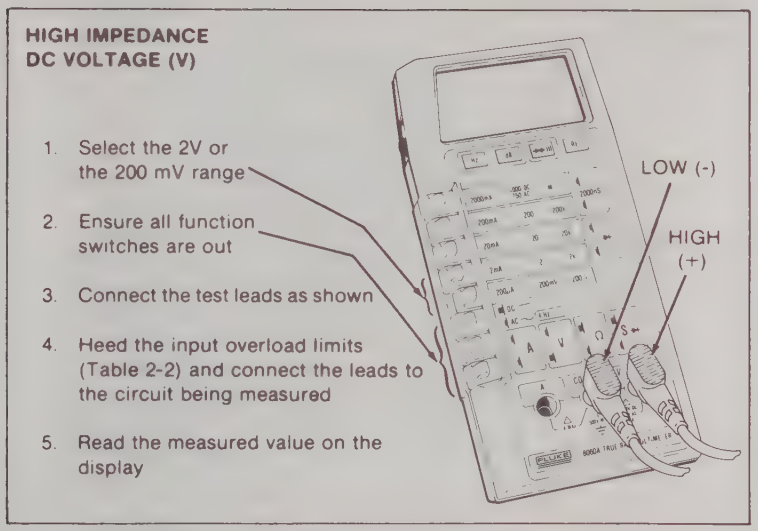

HIGH IMPEDANCE
DC VOLTAGE (V)
1. Select the 2V or the 200 mV range
2. Ensure all function switches are out
3. Connect the test leads as shown
4. Heed the input overload limits (Table 2-2) and connect the leads to the circuit being measured
5. Read the measured value on the display
LOW (-)
HIGH (+)

Figure 2-9. High Impedance DC Voltage

2-15. HIGH IMPEDANCE DC VOLTAGE

Occasionally you may want to make dc voltage measurements in high impedance circuitry where even the 10 MΩ input impedance for the normal dc voltage function could load the circuit and cause significant errors. For example, a 10 MΩ input impedance causes a 0.1% error when measuring the voltage across the 10 kΩ leg of a 90 kΩ over 10 kΩ voltage divider. The 8060A offers a >1,000 MΩ (typically >10,000 MΩ) input impedance dc voltage function which greatly reduces this error.

Figure 2-9 describes how to select the high input impedance dc voltage function (the ac voltage function does not operate in this mode). Notice that all of the function switches must be out to select this function. Either the 2V or the 200 mV range may be selected. Refer to Section 3 for more applications of this function, including a technique for using the 8060A as an electrometer tc measure extremely low currents.

NOTE

When taking measurements in the high impedance dc voltage function, do not select any ranges except the 2V or 200 mV ranges. Measurement in other ranges will result in erroneous readings.

NOTE

When the high impedance dc voltage function is selected and no input is applied, noise from the environment (such as rf or power line noise) may cause the 8060A to display OL (overrange).

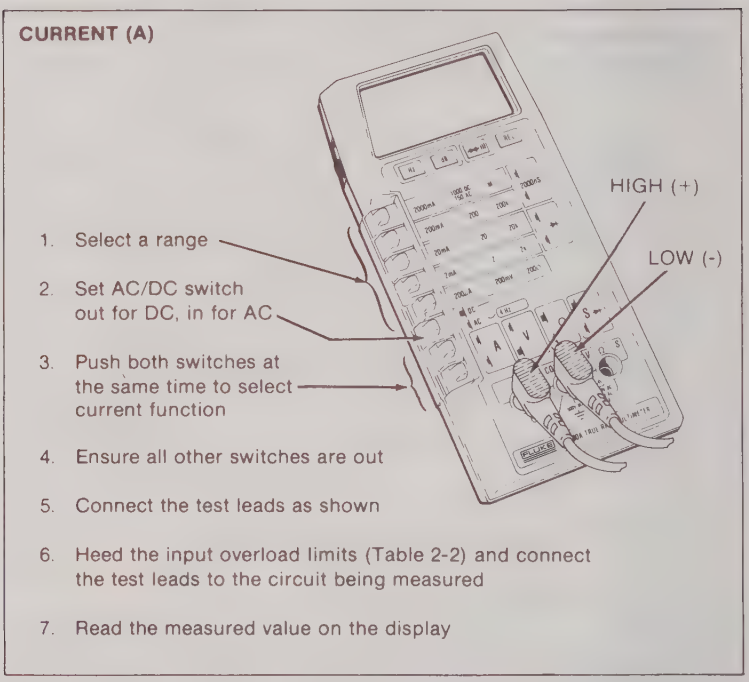

CURRENT (A)
HIGH (+)
LOW (-)
1. Select a range
2. Set AC/DC switch out for DC, in for AC
3. Push both switches at the same time to select current function
4. Ensure all other switches are out
5. Connect the test leads as shown
6. Heed the input overload limits (Table 2-2) and connect the test leads to the circuit being measured
7. Read the measured value on the display

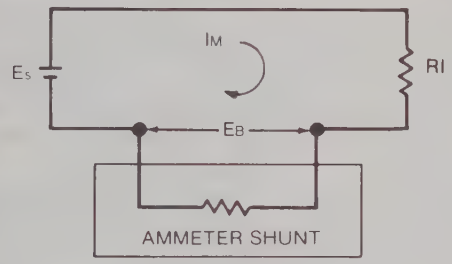
Figure 2-10. Current Operation

2-16. AC/DC Current (A)

Selection of the ac or dc current (A) function is described in Figure 2-10. The 8060A offers five ac (true rms ac-coupled) and five dc current ranges: 200 μA, 2 mA, 20 mA, 200 mA, 2000 mA. Each range is protected by a 2A/250V fuse in series with a 3A/600V fuse.

When a meter is placed in series with a circuit to measure current, you may have to consider an error caused by the voltage drop across the meter (in this case, across the protective fuses and current shunts). This voltage drop is called the burden voltage. The maximum full-scale burden voltages for the 8060A are 0.3V for the four lowest ranges and 0.9V for the highest range.

These voltage drops can affect the accuracy of a current measurement if the current source is unregulated and the resistance of the shunt and fuses represents a significant part (1/1000 or more) of the source resistance. If burden voltage does present a problem, you can calculate the error by using the formula in Figure 2-11. You can minimize this error by selecting the highest current range that provides the necessary resolution.



Es = Source voltage
Rl = Load resistance + Source resistance
Im = Measured current (display reading in amps)
Eb = Burden voltage (calculated)
Eb = meas. current [(200/current range in mA) +.35]

ERROR:

Error in % = 100 x Eb/(Es - Eb)
Error in A = (Eb x Im)/(Es - Eb)

EXAMPLE:

Es = 15V
Rl = 100 kΩ
Im = 148.51 μA (.14851 mA)

$Eb = 148.51 \times 10^{-6} \times [(200/.2) + .35]$

$= 148.51 \times 10^{-6} \times 1000.35 = 148.56$ mV

Max. error in % = 100 x [148.56 mV/(15V - .14856V)] = 1.0003%

Add this to the range spec. accuracy:

Max. error in % = 1.0003% ±(.2% + 2 digits)

Max. error in A = (148.56 mV x 148.51 μA)/(15000 mV - 148.56 mV)

= 1.486 μA

Add 1.486 μA to the reading for correct current

Figure 2-11. Calculating Burden Voltage Error

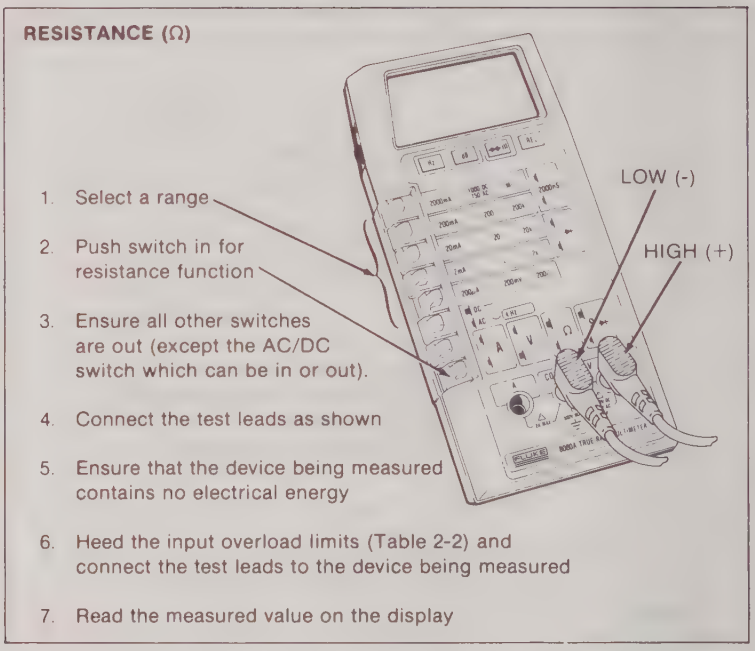

RESISTANCE (Ω)
1. Select a range
2. Push switch in for resistance function
3. Ensure all other switches are out (except the AC/DC switch which can be in or out).
4. Connect the test leads as shown
5. Ensure that the device being measured contains no electrical energy
6. Heed the input overload limits (Table 2-2) and connect the test leads to the device being measured
7. Read the measured value on the display
LOW (-)
HIGH (+)

Figure 2-12. Resistance Operation

2-17. Resistance (Ω)

Selection of the resistance function is described in Figure 2-12. There are four fixed ranges (200Ω, 2 kΩ, 20 kΩ, 200 kΩ) plus the autoranging MΩ range consisting of three ranges: 2 MΩ, 20 MΩ, and 300 MΩ.

In all fixed resistance ranges (200Ω to 200 kΩ), the test voltage is less than that required to turn on most semiconductor junctions. This feature, sometimes referred to as "low power" ohms, aids in troubleshooting by allowing you to measure resistors independent of the effects of in-circuit transistors and diodes. For the fixed ranges the maximum full scale voltage across the circuit being measured is less than 250 mV. The autoranging MΩ ranges have enough voltage to turn on semiconductor junctions (maximum 2.5V full scale), but the current is very low (2.2 μA maximum).

Resistance measurements for all ranges are made using a two-wire ratiometric technique. This means that test lead resistance may affect the accuracy in the 200Ω range. You can correct this error by shorting the test leads together, reading the test lead resistance, and then subtracting it from resistance readings. The most convenient way to do this is with the relative function as described later in this section. This technique is also useful for removing the 0.02Ω error factor in the 200Ω range (refer to resistance specifications in Section 1).

2-18. AUTORANGING MEGOHMS

When the autoranging MΩ range is selected, the 8060A automatically selects the range appropriate for the measurement. The measurement resolution decreases in the two higher MΩ ranges as shown in Table 2-3. Readings made at the crossover points between ranges are microcomputer-stabilized by an offset in the upscale and downscale directions. Range changes are made at 2.00 MΩ and 20.00 MΩ as readings go upscale, or at 19.0 MΩ and 1.90 MΩ as readings go downscale.

Table 2-3. Resistance Function Autoranges and Resolution

RANGE			RESOLUTION	NO. OF DIGITS POSSIBLE IN READING
MΩ Auto-Range	2 MΩ		100Ω	4½
	20 MΩ		10 kΩ	3½
	300 MΩ	20 to 99.9 MΩ 100 to 300 MΩ	100 kΩ 1 MΩ	3 3
kΩ Auto-Range	2 kΩ 20 kΩ		0.1Ω 10Ω	4½ 3½
	300 kΩ	20 to 99.9 kΩ 100 to 299 kΩ	100Ω 1 kΩ	3 3

2-19. AUTORANGING KILOHMS

Although it is not indicated on the front panel, there is an additional autoranging range available: the autoranging kΩ range, which consists of 2 kΩ, 20 kΩ, and 300 kΩ ranges. To select this range, you must simultaneously press the MΩ and the 200Ω switches as shown in Figure 2-13. Like the autoranging MΩ ranges, the autoranging kΩ ranges have enough voltage to turn on semiconductor junctions. Note that the use of the relative function with the autoranging kΩ ranges is restricted to the autoranging kΩ ranges. Refer to the description of the relative function for more information. The autoranging kΩ has the same decrease in resolution (see Table 2-3) and the same display hysteresis as the autoranging MΩ.

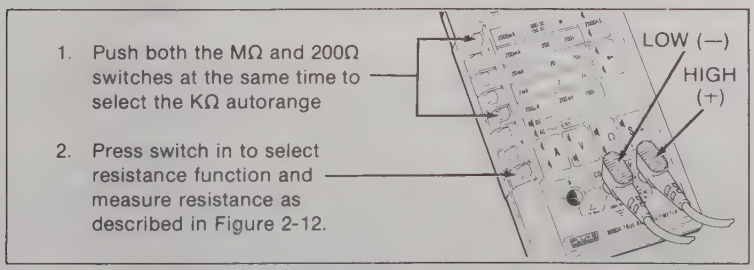

1. Push both the MΩ and 200Ω switches at the same time to select the KΩ autorange
2. Press switch in to select resistance function and measure resistance as described in Figure 2-12.
LOW (—)
HIGH (+)

Figure 2-13. Selection of Autoranging Kilohms

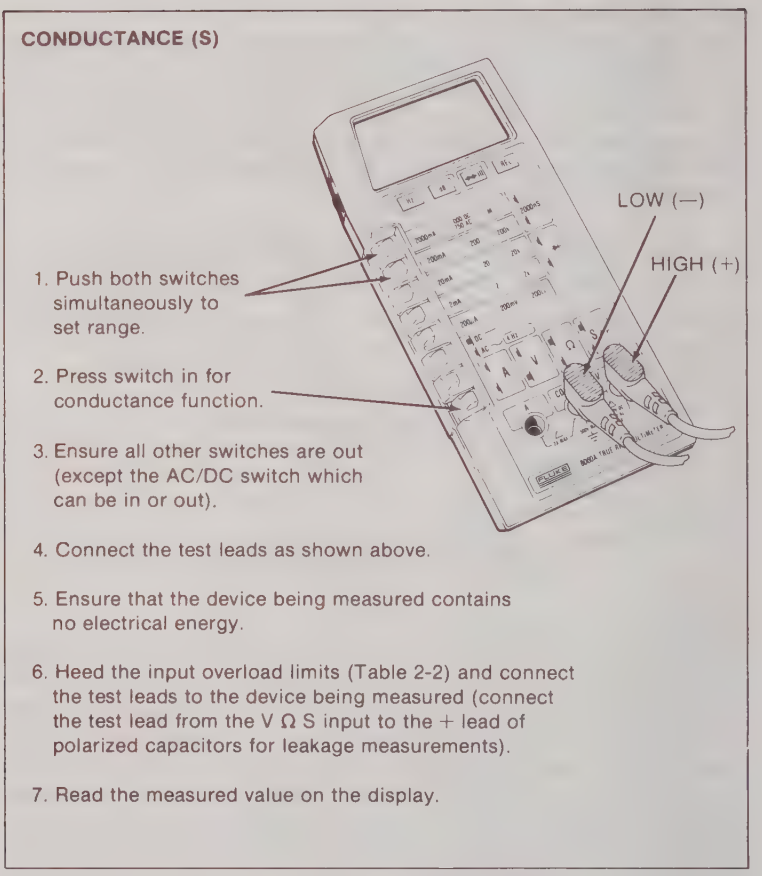

CONDUCTANCE (S)
LOW (—)
HIGH (+)
1. Push both switches simultaneously to set range.
2. Press switch in for conductance function.
3. Ensure all other switches are out (except the AC/DC switch which can be in or out).
4. Connect the test leads as shown above.
5. Ensure that the device being measured contains no electrical energy.
6. Heed the input overload limits (Table 2-2) and connect the test leads to the device being measured (connect the test lead from the V Ω S input to the + lead of polarized capacitors for leakage measurements).
7. Read the measured value on the display.

Figure 2-14. Conductance Operation

2-20. Conductance (S)

Selection of the conductance function is described in Figure 2-14. The range is 2000 nS (nS = nanosiemens or 10^{9} siemens, 1 siemen = 1 Ω) which corresponds to a resistance range from 500 kΩ to 10,000 MΩ.

Conductance is a good way to measure high resistances, such as leakages in diodes, capacitors, pcbs, or insulators. For example, you can measure the conductance of a pcb and then convert the measurement to resistance by referring to Figure 2-15. If you are measuring the leakage of a capacitor, be sure to discharge it first by shorting its leads together. The positive (+) lead of polarized capacitors should be connected to the VΩS input.

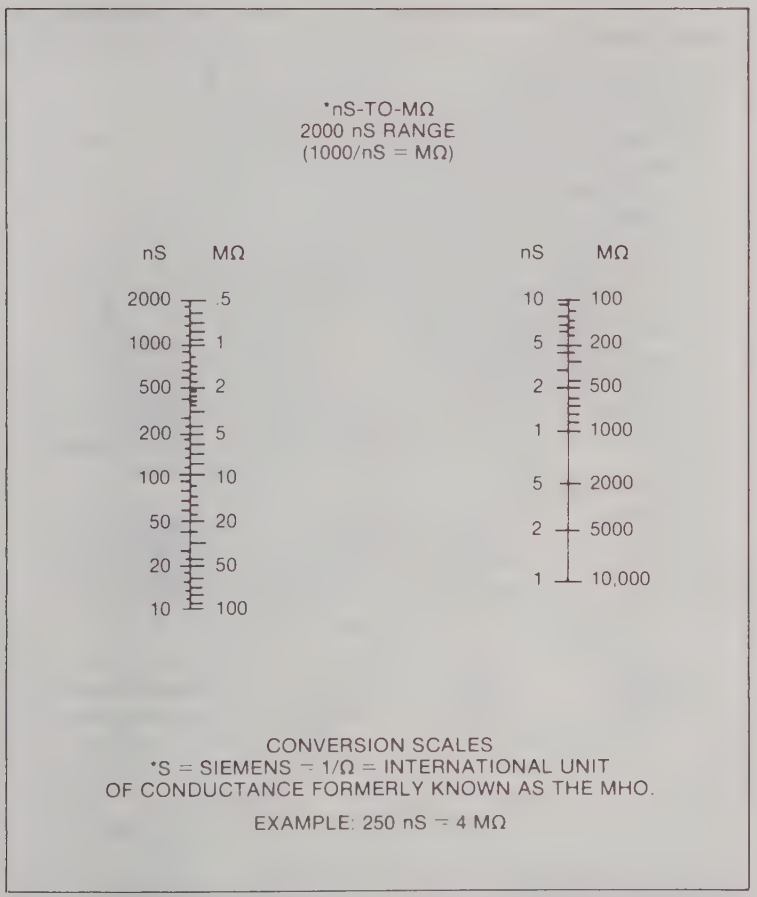


Figure 2-15. Conductance/Resistance Conversion

You may encounter situations where conductance is more convenient to measure than resistance. For example, the resistance of a photodiode is inversely proportional to the available light, i.e. as light increases, resistance decreases. This might be confusing if you want to examine the response of the component over a range of values. However, since conductance is the reciprocal of resistance, photodiode conductance is directly proportional to available light. As light increases, conductance increases. It might be easier to examine the photodiode response in terms of conductance, and then convert the measurements to resistance values if desired.

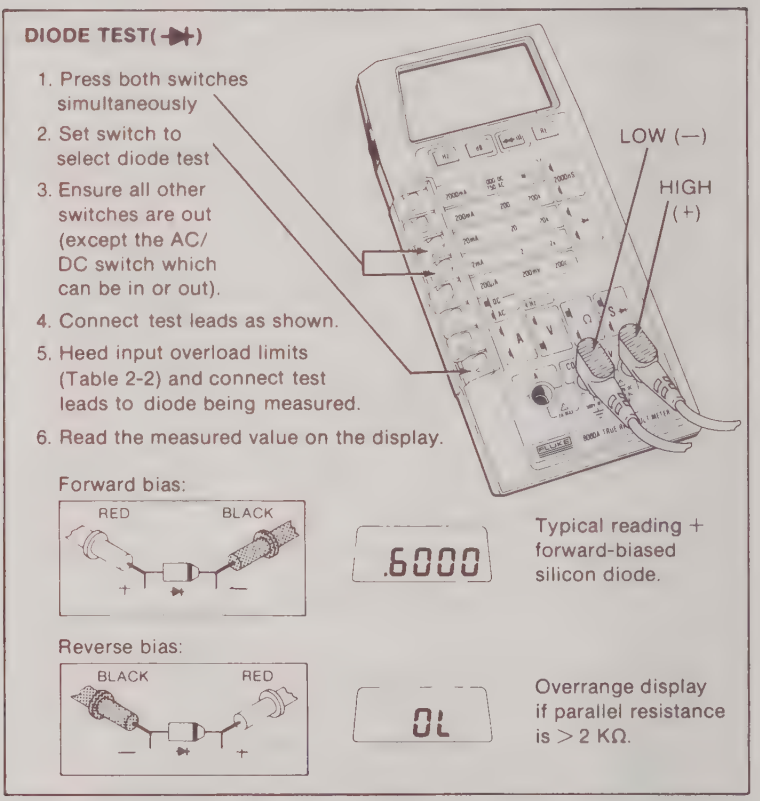

DIODE TEST(⊣▶⊢)
1. Press both switches simultaneously
2. Set switch to select diode test
3. Ensure all other switches are out (except the AC/DC switch which can be in or out).
4. Connect test leads as shown.
5. Heed input overload limits (Table 2-2) and connect test leads to diode being measured.
6. Read the measured value on the display.
LOW (—)
HIGH (+)
Forward bias:
RED
BLACK
+
—
.6000
Typical reading + forward-biased silicon diode.
Reverse bias:
BLACK
RED
—
+
OL
Overrange display if parallel resistance is > 2 KΩ.

Figure 2-16. Diode Test

2-21. Diode Test (⊣▶⊢)

Selection of the diode test is described in Figure 2-16. Notice how the test leads are placed to forward-bias or reverse-bias the diode in the figure.

The diode test measures the forward voltage of a semiconductor junction (or junctions) at a 1 mA test current. Readings are displayed in the 2V range, with OL displayed for voltages greater than 2V. For a silicon diode, the typical forward voltage at 1 mA is about 0.6V. A reverse-biased semiconductor junction should display the overrange (OL) indicator provided that any resistance parallel to the junction is greater than 2 kΩ.

A quick way to check for shorted or open junctions is to reverse the test leads. If the junction indicates the same in-scale reading both directions, it is probably shorted. If the junction indicates an overrange both directions, it is open.

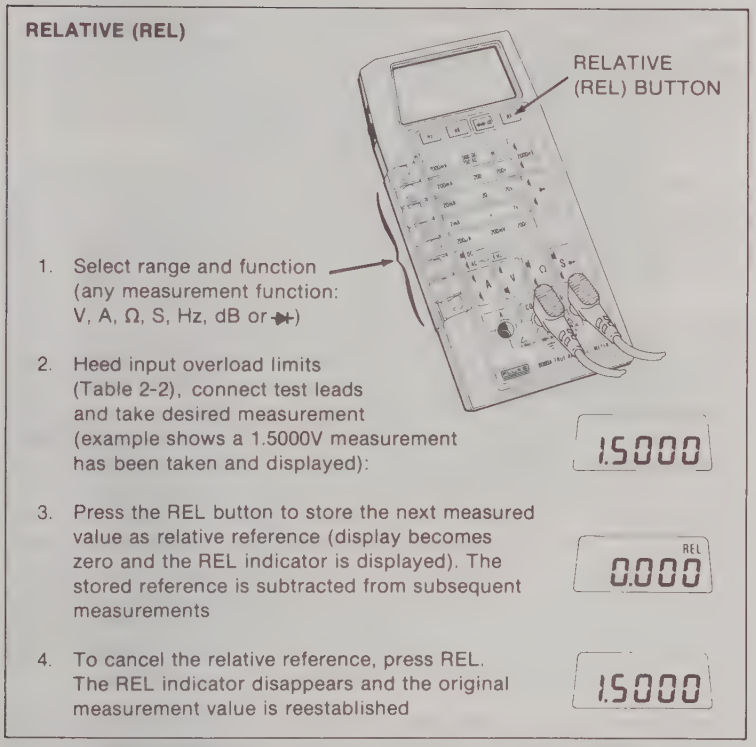

RELATIVE (REL)
RELATIVE
(REL) BUTTON
1. Select range and function (any measurement function: V, A, Ω, S, Hz, dB or →|←)
2. Heed input overload limits (Table 2-2), connect test leads and take desired measurement (example shows a 1.5000V measurement has been taken and displayed):
1.5000
3. Press the REL button to store the next measured value as relative reference (display becomes zero and the REL indicator is displayed). The stored reference is subtracted from subsequent measurements
REL
0.000
4. To cancel the relative reference, press REL. The REL indicator disappears and the original measurement value is reestablished
1.5000

Figure 2-17. Relative (REL) Operation

2-22. Relative (REL)

The relative function allows you to store any reading as an offset or relative reference value. When you press the REL button, the REL indicator appears in the upper right corner of the display, and the 8060A stores the next measurement in a register along with the function and range. Subsequent measurements are displayed as the difference between the measured value and the stored relative reference (refer to Figure 2-17).

For example, if a reading of 1.0000V dc is displayed when the REL button is pressed (the display will read 0.0000 after REL is pressed), subsequent readings will have 1.0000 subtracted from them. If the next measurement is 1.2700V dc, the reading displayed will be .2700. If the next measurement is 0.8500V dc, the reading displayed will be -.1500. You may cancel the relative reference by pressing the REL button (the REL indicator disappears from the display), by turning the instrument off, or by storing a relative reference with another function.

If you change ranges, the relative reference is automatically multiplied or divided by the appropriate power of ten before being subtracted from the measurement. If you change functions, the REL indicator disappears and the relative reference is stored with the original function. When you reselect the function, the relative reference is restored (the REL indicator reappears) unless a new relative reference was established in another function.

The relative function may be used with all the measurement functions: ac or dc voltage, ac or dc dB, ac or dc current, resistance, conductance, diode test, and frequency. When used with continuity, the relative function stores the accompanying resistance readings. Note that the input overload limits are not changed by the use of the relative function.

Another thing to be aware of when using relative reference is that the range of possible readings is still subject to the limits of the display and the 19999 counts of the analog-to-digital (a/d) converter, regardless of the relative reference. For example, suppose the instrument is in the dc voltage function with the 20V range selected, and you store a relative reference of 15V. The maximum positive relative voltage reading that can be displayed without overranging is 4.999V, which is actually a 19.999V input signal. Any input signal greater than 19.999V exceeds the 19999 counts of the a/d converter. The minimum (negative) voltage reading that may be displayed without overranging is -19.999V, which is a -4.999V input signal. You can avoid this situation by selecting a higher range.

Remember that even though the REL indicator appears on the display almost instantaneously after the REL button is pressed, the relative reference is not stored until the next measurement takes place. For most functions, the time between measurements is about 0.4 seconds (frequency measurements occur every second, and dB measurements occur about every 1.4 seconds).

A typical way to use the relative reference is to correct for test lead resistance. Although test lead resistance is usually very small (typically0.5 to 5Ω), it can be significant when measuring low resistances. To correct for it, select the desired resistance range, short the test leads together, and press the REL button. The REL indicator will appear and the display will read zero. The 8060A will automatically subtract the stored test lead resistance from subsequent measurements. Other common applications for relative reference include: offset nulling (dc and ac voltage or current), amplifier matching (dB), power line frequency deviation (Hz), diode and transistor matching (diode test), resistor matching (Ω), and voltage deviation (ac and dc voltage).

NOTE

The use of the relative function with the autoranging kΩ ranges is restricted to the autoranging kΩ ranges. If you take a reference reading within the autoranging kΩ range and then use it as a reference outside autoranging kΩ, or use a reference reading taken outside autoranging kΩ within autoranging kΩ, errors will result. There is no restriction on the use of the relative function with the fixed resistance ranges or with autoranging MΩ.

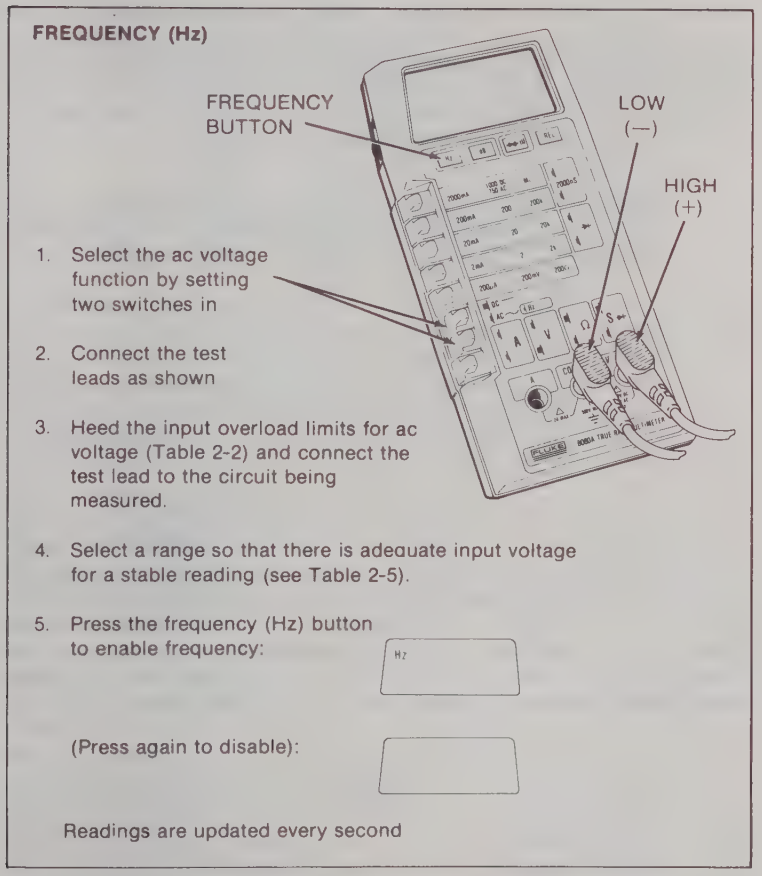

FREQUENCY (Hz)
FREQUENCY BUTTON
LOW (—)
HIGH (+)
1. Select the ac voltage function by setting two switches in
2. Connect the test leads as shown
3. Heed the input overload limits for ac voltage (Table 2-2) and connect the test lead to the circuit being measured.
4. Select a range so that there is adequate input voltage for a stable reading (see Table 2-5).
5. Press the frequency (Hz) button to enable frequency:
Hz
(Press again to disable):
Readings are updated every second

Figure 2-18. Frequency (Hz) Operation

2-23. Frequency (Hz)

The selection of the frequency function is described in Figure 2-18. Frequency selection is cancelled if you select a different function (resistance or ac voltage dB, for example).

The frequency function is fully autoranging over four ranges: 200 Hz, 2000 Hz, 20 kHz, and 200 kHz. Depending on the frequency of the ac input signal, the 8060A automatically selects the proper range and displays the appropriate measurement unit, either Hz or kHz. Frequencies less than 12.2 Hz are not measured reliably, and frequencies greater than 199.99 kHz cause the OL overrange indicator to appear.

When you press the Hz button to select the frequency function, the Hz indicator appears in the display almost immediately, and the first frequency reading is displayed within one second. The 8060A has a one-second reading rate for all ranges (except for frequencies between 12 and 16 Hz, which respond in 1 to 1.3s), including the .01 Hz and .1 Hz resolution readings in the 200 Hz and 2000 Hz range. The resolution for each range is listed in Table 2-4.

Table 2-4. Frequency Function Autoranges and Resolution

FREQUENCY RANGE	RESOLUTION
200 Hz	.01 Hz
2000 Hz	.1 Hz
20 kHz	1 Hz
200 kHz	10 Hz
>200 kHz Extended Range*	100 Hz
*Extended range enabled by holding down the Hz button at power-on.	

The minimum input signal that is required to trigger the frequency counter varies, depending on the ac voltage range selected and the frequency. The input signal sensitivity is listed in Table 2-5. The values are based on rms sine waves. You must increase the signal level for lower crest factor input signals (the crest factor is the ratio of the peak voltage to the ac rms voltage of a waveform) or non-50% duty-cycle signals. If the input signal is below the required level, the 8060A will display 0.00 Hz, and will not take readings. If you find that your readings are unstable, the input signal may be near the threshold level for that range. You can correct this by selecting a lower ac volts range.

Table 2-5. Sensitivity for the Frequency Function

INPUT SIGNAL	SENSITIVITY (based on sine wave V rms)
12 Hz to 20 kHz	20 mV or 10% of voltage range*
20 kHz to 100 kHz	50 mV or 25% of voltage range*
100 kHz to 200 kHz	150 mV or 75% of voltage range*
*Whichever value is greater	

The maximum input voltage that may be applied depends on the ac voltage range. The maximum inputs are listed in Table 2-6.

CAUTION

No voltage overrange indication is given when the 8060A is measuring frequency. To prevent possible instrument damage, do not exceed 750V ac rms or a volt-hertz product of 1×10^7 when measuring frequency.

Table 2-6. Maximum Input Voltages for the Frequency Function

AC VOLTAGE RANGE	MAXIMUM USEABLE AC VOLTAGE*
200 mV	±5V peak
2V	±50V peak
20V	±500V peak
200V	±1000V peak
750V	±1000V peak
*Signal not to exceed a volt-hertz product of 1×10^7.	

In addition to the four usual frequency ranges, there is an extended frequency range that may be enabled. To enable the extended frequency range, hold down the Hz button as you turn on the instrument. After the power-on self-test has been completed (the display is .8.8.8.8), release the Hz button. Now when you select the frequency function, the autoranging can extend beyond the 200 kHz range. The 200 mV ac voltage range is recommended for frequencies above 200 kHz. Normally this frequency range is not enabled because of loss of sensitivity above 200kHz, but typically you can measure 420 kHz TTL level signals (50% duty cycle). When the instrument is turned off, the extra range is disabled.

2-24. Decibel (dB)

The selection of dB is described in Figure 2-19. Like frequency, dB is automatically cancelled if you select another function (resistance or frequency, for example).

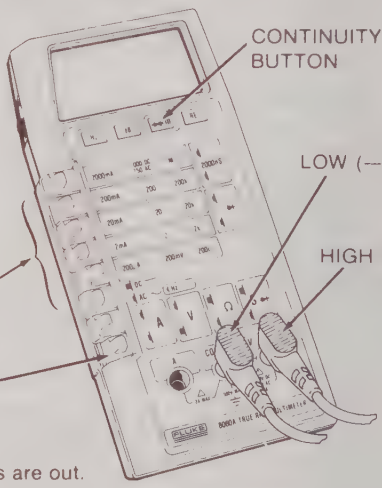
When dB is selected, the 8060A microcomputer converts ac or dc voltage readings to the dBm equivalent (decibels above or below one milliwatt). The standard reference impedance is 600Ω. You can make dB measurements independent of the reference impedance by using the relative function in conjunction with the dB function. You can also modify the reference impedance by applying and storing a voltage equivalent to 0 dBm referenced to the desired impedance. Refer to Section 3 for details.

Note that the 8060A performs a 'bridging' measurement when measuring dBm, which assummes the reference load is part of the system. When making 'terminating' measurements (such as testing a phone line without a phone connected) be sure to apply the proper load to the 8060A. For example, if you are making a terminating dBm measurement in a 600Ω system with 50V maximum signal levels, place a 600Ω 5 watt resistor across the 8060A input terminals.

The ac dB dynamic range is from -50.0 to 59.72 dBm (109.72 dBm total). The dc dB dynamic range is from -74 to 62.22 dBm (136.22 dBm total). For readings greater than approximately 5% of full-scale for the voltage range selected, the resolution is .01 dB. Below approximately 5% of scale, resolution drops off to .1 dB, and below approximately 0.6% of scale, resolution is 1 dB. Anytime blank digits appear to the right of the decimal point, it is an indication that resolution has fallen off and you need to select a lower range.

Be careful not to short the battery by connecting the side contact to the center pin. Battery voltage should read 5.2V to 10V. If the voltage is less than 5.2V, the battery should be replaced.

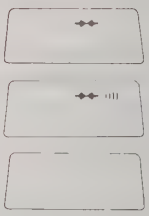
CONTINUITY (⊶)



1. Select range.
2. Set switch in for resistance function.
3. Ensure that other switches are out.
4. Press the ⊶ button once to enable visible continuity:

   Press the ⊶ button again to enable audible continuity:

   (Press again to disable both):



5. Connect the test leads as shown.
6. Ensure that the device being measured contains no electrical energy. Heed the input overload limits (Table 2-2), and connect the test leads to the circuit.
7. Observe the display for visible continuity indicated by the bar:

   Or listen for tone indicating audible continuity:

BEEEEP

Figure 2-20. Continuity (⊶) Operation

WARNING

THE LOCAL LINE VOLTAGE IS MEASURED IN THE FOLLOWING STEP. BE CAREFUL NOT TO TOUCH THE PROBE TIPS WITH YOUR FINGERS, OR TO ALLOW THE PROBE TIPS TO CONTACT EACH OTHER.

2. AC VOLTAGE, dB, FREQUENCY - Select the ac voltage function and the 200V range. Take note of the preceding warning and insert the probe tips into a standard wall socket. The display should read the local line voltage.

Now push the dB button. The display should read the line voltage in dB.

Now push the Hz button. The display should read the frequency of the line voltage. Carefully remove the probe tips from the wall socket.

3. RESISTANCE, CONTINUITY, CONDUCTANCE, DIODE TEST - Select the resistance function and the 2 kΩ range. Touch the red (VΩS) probe tip to the A jack so the VΩS input is shorted to the A input (this is the fuse check procedure from Section 2-4). The display should read .1000 ±.0100 kΩ (neglecting lead resistance).

Push the ⊶))) button twice to enable the visible and audible continuity. You should see the bar in the display and hear the tone.

Select the diode test (with the VΩS and A inputs still shorted together). The display should read .0102 ±.0015V.

Select the conductance function (with the VΩS and A inputs still shorted together). The instrument should indicate overrange (OL). Remove the connection between the inputs. The instrument should indicate 0.0 ±1.0.

Section 3
Applications

3-1. INTRODUCTION

With its unique combination of features such as true rms, frequency, dB, relative reference and the 4-1/2 digit display, the 8060A offers a wide variety of measurement capabilities, including measurement of amplifier bandwidth, the Q factor, amplifier stage gain in relative dB, and some other general audio applications. You can also find out how to change the dB reference impedance or how to use the 8060A to measure extremely low currents. These applications may be of immediate use to you, or they may help you discover other ways the 8060A can fill your measurement needs.

3-2. DETERMINING AMPLIFIER BANDWIDTH

The following procedure describes how to use the ac voltage dB, relative, and frequency functions to determine the bandwidth of an amplifier (for frequencies up to 100 kHz):

1. Connect the amplifier, signal generator, load, and 8060A as shown in Figure 3-1.

2. On the 8060A, select the ac voltage function and a range appropriate for the amplifier output.

3. Adjust the signal generator for a signal level that is within the input operating range of the amplifier. Beginning at a low frequency (20 Hz), steadily increase the frequency until the ac voltage reading on the 8060A begins to rise. Typically the ac voltage readings will rise to a peak, level out, and then begin to fall, much like the response curve shown in Figure 3-1. (High quality audio amplifiers will probably not show a rise in readings since they are generally flat from 20 Hz to >20 kHz. In this case, use 1 kHz as a midband reference for 0 dB in Step 4).

4. When the peak or the upper plateau of ac voltage readings has been reached, press the dB button and then the REL (relative) button on the 8060A. This establishes the 0 dB relative reference.

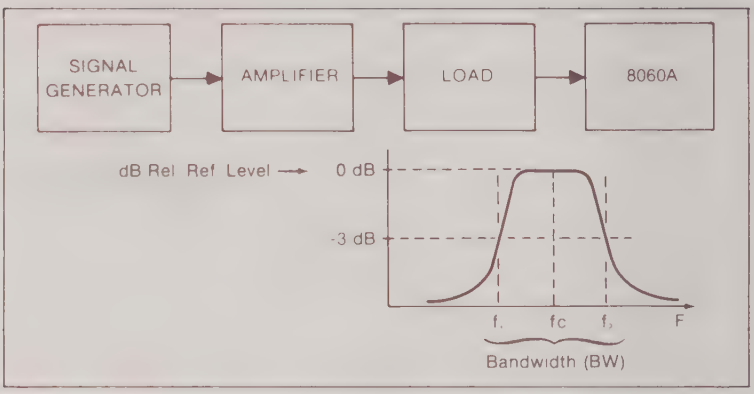


Figure 3-1. Measuring Amplifier Bandwidth

5. Increase the frequency input until the dB readings drop to −3.00 dB. Press the Hz button on the 8060A to read the upper frequency limit of the bandwidth. Press the dB button to restore the dB reading.

6. Decrease the frequency input so the dB readings rise to 0 dB and then drop again to −3.00 dB. Press the Hz button to read the lower frequency limit of the bandwidth.

You can use a similar technique to examine the performance characteristics of frequency-sensitive filters, such as high or low-pass filters, notch filters, etc. With the 4-1/2 digit frequency resolution and the 0.01 dB resolution, you can very accurately determine the rolloff, slope, and bandpass.

3-3. USING THE 8060A AS A Q-METER

You can use the 8060A to determine the Q factor of a tuned circuit (refer to Figure 3-2). First use the technique presented in Section 3-2 to determine the center frequency (fc) and bandwidth of the circuit (for tuned circuits, the center frequency of the bandwidth is found at the peak or midway within the high plateau of the dB readings). Then calculate the Q of the circuit by using the following formula:

$$Q = fc / \text{Bandwidth}$$

3-4. MEASURING AMPLIFIER STAGE GAIN WITH RELATIVE dB

When testing multi-stage amplifiers, we are usually interested in the dB gain or loss at each stage referenced to an initial dB level. Figure 3-3 shows an example of this kind of application with the 8060A. A 20 mV signal is applied to the first stage of a three-stage amplifier. The signal is measured with the 8060A in the ac voltage function. Then the dB button is pressed followed by the REL button which creates the relative reference 0 dB point. Each stage is then measured, and the 8060A displays the dB level with reference to the initial input.

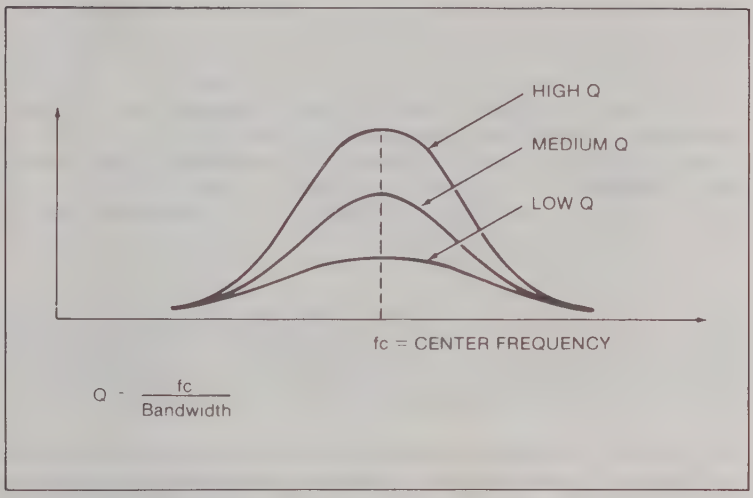


Figure 3-2. Measuring Q with the 8060A

1. Apply 20 mV to the first-stage input and measure it with the 8060A ac voltage function.

2. Press the dB button and then the REL button to create the 0 dB relative reference.

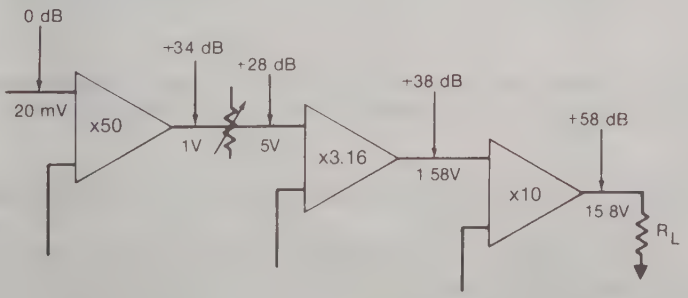


Figure 3-3. Measuring Stage Gain with Relative dB

3-5. GENERAL AUDIO USES

You can perform many audio equipment tests using the 8060A with a minimum of other equipment. For example, connect the 8060A to the tape recorder output sockets of a phono amplifier with a shielded lead. Select the ac voltage dB function and the 200 mV range. Then play a frequency response test record (they are available at some of the larger audio equipment stores). You can establish a reference level by pressing the REL button while a particular frequency is being played. The signal level of all the other frequencies on the disc will be displayed in dB with reference to the original reference level. If you connect the 8060A to the speaker sockets of an audio amplifier and play the frequency response test record, you can adjust the filters and tone controls and check their performance.

The 8060A is also useful for a variety of maintenance tasks when servicing tape decks. Some of these tasks include setting up record and playback levels during calibration, head alignment, checking attenuator pads, and testing equalizers. Refer to manufacturer information for procedures.

3-6. USING THE 8060A TO MEASURE EXTREMELY LOW CURRENTS

By using the high impedance dc voltage function and high MΩ precision resistors, you can use the 8060A to measure extremely low currents. For example, if you place a 100 MΩ resistor across the 8060A and select the high impedance dc voltage function and the 200 mV range, the 8060A will measure a 2 nanoamp (10^{-9}A) current with 0.1 picoamp (10^{-12}A) resolution.

The error sources with this method of measurement are the combined accuracy specifications for the voltage range and the resistor, as well as the 8060A input bias current. The input bias current is typically 10 picoamps. You can measure the input bias current error by removing the test leads and selecting the normal dc voltage function and the 200 mV range. The number of digits in the display reading indicates the input bias current in picoamps (disregard the decimal point). You can correct for the input bias current by using the relative reference to zero the offset.

The best measurement results will be obtained at ordinary room temperature with low relative humidity. Be sure to use adequate shielding to prevent power line or rf interference.

3-7. MAKING dBm OR dBW MEASUREMENTS WITH OTHER REFERENCE IMPEDANCES

The standard power-on reference impedance for 8060A dBm (decibels above or below one milliwatt) measurements is 600Ω, which is the most common reference impedance used in the data communications and audio fields. However, occasionally you might want to make measurements with a different reference impedance. For instance, the standard rf dBm reference impedance is 50Ω. Audio power amplifiers use dBW (decibels above or below one watt) referenced to 2, 4, 8, or 16Ω. The standard method for making these dBm or

dBW measurements is to add or subtract a correction factor. With the 8060A, however, you can set up any of these reference impedances with the relative (REL) function.

To change the reference impedance, select the desired dB function and appropriate range, apply the equivalent voltage level obtained from Table 3-1 (or from the formulas at the bottom of Table 3-1), and press the REL button. The 8060A will store the equivalent voltage level, and subsequent dB measurements will be referenced to the new impedance.

For an example of how to use this feature, let's assume that you want to make ac voltage dBm measurements referenced to 50Ω. First select the 8060A ac voltage dB function and the 2V range. Referring to Table 3-1, we find that the equivalent voltage level for 0 dBm for 50Ω is 0.2236V and the equivalent dB level for 0 dBm referenced to 600Ω is -10.79 dBm. Apply an ac voltage to the 8060A input (VΩS and COMMON) and adjust the applied voltage level until the 8060A displays -10.79. Now press the REL button. The display should read 0.00 (with the dB

Table 3-1. Equivalent Voltage Levels for Modifying the Reference Impedance

REFERENCE IMPEDANCE Z (Ω)	EQUIV. VOLTAGE LEVEL	EQUIV. dB LEVEL FOR 0 dBm REF. TO 600Ω AS SHOWN ON THE 8060A DISPLAY (dBm)
50	FOR 0 dBm (V) 0.2236	-10.79
75	0.2739	-9.03
90	0.3000	-8.23
125	0.3536	-6.81
150	0.3873	-6.02
300	0.5477	-3.01
600 (power-on value)	0.7746	0.00
900	0.9487	1.76
1000 (dBV)	1.0000	2.22
2	FOR 0 dBW (V) 1.4142	5.23
4	2.000	8.24
8	2.828	11.26
16	4.000	14.26

Use the following formulas to calculate equivalent voltage levels for reference impedances not listed.

For dBm: 0 dBm level (V) = $\sqrt{.001 \times \text{desired ref. impedance } (\Omega)}$

600Ω Ref. Equiv. (dBm) = 20 log [0 dBm level (V)/.7746]

For dBW: 0 dBW level (V) = $\sqrt{\text{desired ref. impedance } (\Omega)}$

600Ω Ref. Equiv. (dBm) = 20 log [0 dBW level (V)/.7746]

and REL indicators at the top of the display). Measurements taken with the ac voltage dB function will now read dBm referenced to 50Ω.

Whenever you use Table 3-1, be sure you start with the 600Ω reference impedance selected on the 8060A. Otherwise the values and formulas listed in Table 3-1 will be incorrect because they use the 600Ω reference impedance as a starting point.

After a reference impedance is stored with the REL button, the reference impedance will remain stored until the instrument is turned off or until another relative value is stored. You can cancel the stored reference by pressing the REL button, in which case the REL indicator will disappear and the reference impedance will revert to the power-on value, 600Ω. You can use other functions without losing a stored reference impedance as long as you do not store some other relative value.

3-8. CHANGING AC dB REFERENCE IMPEDANCES WITH A DC SOURCE

The most straightforward method of changing the reference impedance is to select the desired voltage dB function, apply the equivalent voltage, and press the REL button. However, a precision ac voltage source is not always as readily available as a dc voltage source. There is a method for using a variable 0 to 200 mV dc voltage source to set up virtually any reference impedance for ac voltage dB.

To use this method, place the AC/DC switch in the AC position and place the other two function switches in the out position. Find the equivalent dB level in Table 3-1 and select the appropriate range. Press the dB button. Beginning with a 200 mV input signal, slowly decrease the input signal until the proper dB level is displayed on the 8060A. Then press the REL button. Now you can select the ac voltage dB function and subsequent measurements will be referenced to the modified reference impedance.

Note that in this mode the input signal does not go through the voltage divider or the ac rms converter, but is applied directly to the a/d converter. Since the a/d converter inputs are between 0 and 200 mV for all ac ranges, the voltage you apply will always be between 0 and 200 mV, regardless of the range. For example, let's assume you want to use this method to establish a reference impedance of 90Ω. From Table 3-1 you can see this requires an input of 0.3000V. So you select the 2V range, but you only apply 30 mV dc of signal in the 2V range to make the reading appear to be 300 mV ac. Similarly, 30 mV dc of signal in the 20V range will appear to be 3V ac, and in the 200V range will appear to be 30V ac.

Section 4
Theory of Operation

4-1. INTRODUCTION

This section describes how the 8060A works. An overview of the operation is provided first, followed by descriptions of the two major components and the measurement functions. A detailed schematic of the instrument appears in Section 8.

4-2. FUNCTIONAL DESCRIPTION

The major circuits and components of the 8060A are arranged in a block diagram in Figure 4-1. Two major components make up the measurement system: a four-bit CMOS microcomputer, and a CMOS integrated circuit known as the Measurement Acquisition Chip (MAC). The microcomputer selects the appropriate measurement function in the MAC according to the switches or buttons pushed by the operator. The microcomputer also controls the measurement cycles, performs calculations on measured data, and drives the display. The MAC measures the conditioned input signals with the a/d converter or the frequency counter. The MAC also controls the power supply and the continuity tone generator. The microcomputer and the MAC communicate through a four-bit bidirectional bus and four control lines. Both components are described in more detail later in this section.

As shown in Figure 4-1, the input signals are routed by the range and function switches through the appropriate signal conditioners for input filtering and scale changes. Input signals for all measurement functions except frequency are converted to a proportional dc analog voltage that is applied to the a/d converter. The dual-slope a/d converter converts the dc analog voltage to a digital number that is sent to the microcomputer. Input signals for frequency measurement are ac voltages that are buffered by the ac converter and applied to the frequency counter in the MAC. The frequency counter supplies the digital number to the microcomputer. Each of the major measurement functions are described later in this section.

4-3. Microcomputer

The four-bit CMOS microcomputer senses switch positions by reading status registers in the MAC, and senses button pushes through input lines connected

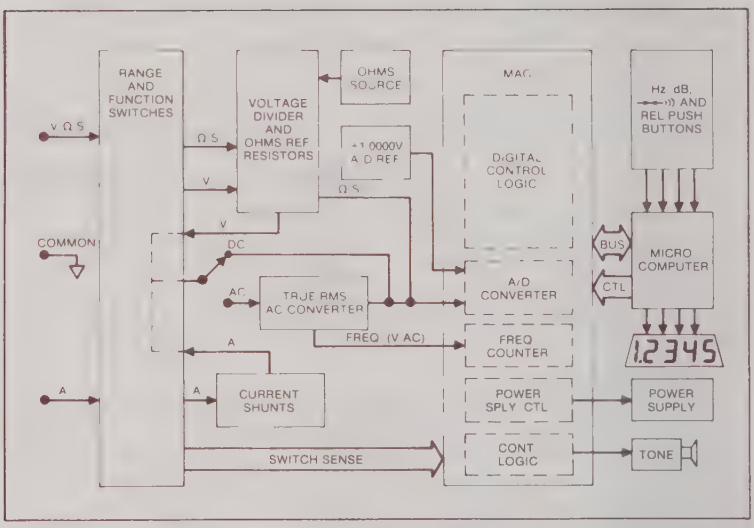


Figure 4-1. 8060A Block Diagram

directly to the microcomputer. The microcomputer processes the information and then selects the appropriate digital and analog configuration in the MAC by writing to an array of MAC control registers.

The operation of the instrument is controlled by software routines that are stored in the microcomputer memory. These routines include the normal operating routine, the power-on self-test, or special self-test routines that may be selected by the operator. When the instrument is first turned on, the microcomputer performs the self-test routine which checks the LCD segments and the interface to the MAC (refer to Section 2 for operating instructions). While the LCD segments are on (a minimum of 1.6 seconds), the microcomputer exercises the bus and checks the internal registers in the MAC to make sure it has control over them. If the microcomputer detects a problem with the MAC interface, it stays in the self-test routine with the LCD segments on until the problem is resolved or the instrument is turned off.

After the power-on self-test routine is successfully completed, the microcomputer checks to see if the operator has selected the ratio self-test or the switch decoding self-test (refer to Section 5 for operating instructions). If neither of the self-tests has been selected, the microcomputer begins the normal operating routine. The operating routine consists of four steps:

1. The microcomputer reads the function and range selections and checks the four push buttons to determine the mode the operator has selected. The microcomputer then selects either the a/d converter (for

measurement of voltage, current, resistance, conductance, continuity, or the diode test) or the frequency counter.

2. The microcomputer initiates either the a/d measurement cycle (approximately 400 ms) or the frequency measurement cycle (approximately 1.0s). The measurement cycles are described later in this section.

3. The microcomputer processes the data obtained in the measurement cycle. This includes calculations for the dB, relative (REL) offset, and MΩ or frequency autoranging.

4. The microcomputer displays the results. The results remain on the display until it is updated.

After the results are displayed, the routine begins again at the first step.

4-4. Measurement Acquisition Chip (MAC)

A block diagram of the MAC is shown in Figure 4-1. The digital control logic includes a buffer and decoder, read and write logic, status and control registers, and logic control for the continuity function. The power supply control uses the calibrated 1V a/d reference voltage obtained from a bandgap reference diode to regulate the 5.2V main power supply for the instrument. When the continuity function is selected and continuity is detected, the MAC generates the tone by supplying a square wave to the external piezoelectic transducer.

4-5. A/D Conversion Cycle

The heart of the MAC is the dual-slope a/d converter. A block diagram of the analog portion of the a/d converter is shown in Figure 4-2. The internal buffer, integrator, and comparators work in conjunction with external resistors and capacitors to convert the dc analog voltage to a digital number. The internal switches are FET switches that are controlled by the microcomputer and the MAC digital control logic. The switchable integrator gain depends on the function and range selected.

The complete a/d measurement cycle is shown in Figure 4-3. It consists of three consecutive time periods: autozero (AZ), integrate (INTEG) and read. A fourth time period, overload (OL) is also used if an overrange reading is taken. The total length of the measurement cycle is 400 ms. The length of the integrate period is fixed at 100 ms. One hundred ms is a multiple of the period of 50 Hz or 60 Hz power, which helps to reduce possible power line noise that might interfere with the measurement. The waveform at the INTEG capacitor is shown for three sample measurement readings: half-scale, full-scale, and overrange.

The measurement cycle begins with the autozero period. The AZ switches close, applying a ground reference as the input to the converter. Under ideal conditions the output of the comparator would also go to zero. However, input-offset voltage errors accumulate in the buffer amplifier loop, and appear at the comparator output as an error voltage. To compensate for this error, the error is

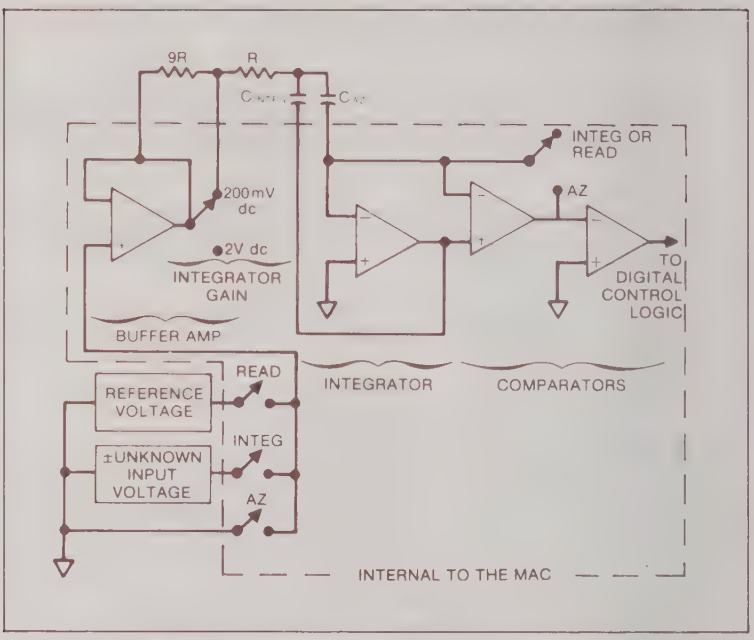


Figure 4-2. Analog Portion of the A/D Converter

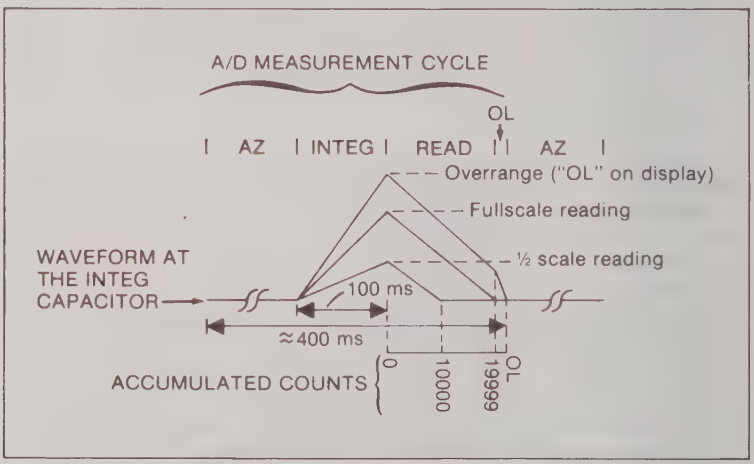


Figure 4-3. A/D Measurement Cycle

impressed across the AZ capacitor where it is stored for the remainder of the measurement cycle. The stored level is used to provide offset voltage correction during the integrate and read periods.

The integrate period begins at the end of the autozero period. As the period begins, the AZ switches open and the INTEG switches close. This applies the unknown input voltage to the input of the converter. The voltage is buffered and then begins charging the INTEG capacitor. The waveform at the INTEG capacitor is a ramp from near zero to some maximum value determined by the amplitude and polarity of the unknown input voltage.

As the read period begins, the INTEG switches open and the READ switches close. This applies the known reference voltage from a "flying" capacitor whose polarity is chosen by the a d converter to be the opposite of the polarity of the unknown input voltage. The INTEG capacitor begins discharging at a fixed rate while a counter begins counting. The counter stops counting when the INTEG capacitor voltage equals the initial autozero voltage. The count is proportional to the unknown input voltage, and is placed on the display by the microcomputer.

If during the read period the counter counts up to the maximum number of counts for a full-scale reading (19999 counts) and the INTEG capacitor charge has not yet reached the initial autozero voltage, the microcomputer knows an overrange reading has been taken. The microcomputer places "OL" on the display and commands the a d converter to go into the overload (OL) period which rapidly slews the integrator voltage back to the initial autozero voltage.

The measurement cycle ends at the end of the read period for an on-scale reading, or at the end of the overload period for an overrange reading. A new measurement cycle then begins with the autozero period. The display update rate for measurement functions that use the a/d converter is approximately 0.4s, or about 2-1/2 readings per second.

4-6. Voltage Measurement

Both the ac and dc voltage ranges use an over-voltage-protected 10 MΩ input divider as shown in Figure 4-4. The over-voltage protection includes two 2-watt fusible resistors and four metal-oxide varistors for high voltage clamping. Depending on the range selected, lower leg resistors of the divider are connected to ground to perform the input signal division.

The dc input voltages for all ranges are divided by the appropriate factor of 10 to produce a proportional dc signal which is then filtered and applied to the input to the a/d converter. The dc and ac voltage ranges and division factors are listed in Table 4-1 along with the corresponding range of inputs to the a/d converter. Notice in Table 4-1 that the 2V dc voltage range is divided by 1 (not 10). The microcomputer compensates by decreasing the integrator gain in the a/d converter by a factor of 10 (refer to Figure 4-2). The integrator gain is also reduced by a factor of 10 in the 1000V dc voltage range, which uses the same divider arrangement as the 200V dc voltage range.

The ac input voltages are divided with the same divider arrangement as the dc input voltages, with the exception that the 2V ac voltage range is divided by 10. The divider output signals for ac voltages are ac-coupled to the input of a true rms ac converter which produces a current output. This negative dc representation is applied through a calibrated scaling resistor. The resultant negative voltage is filtered and applied to the input of the a/d converter.

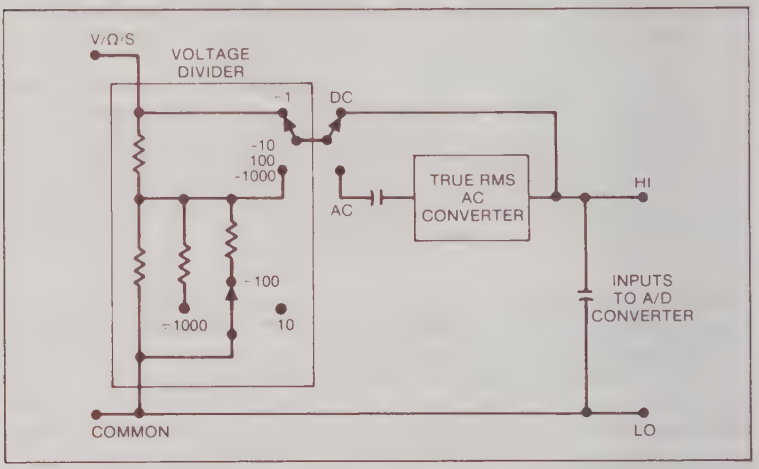


Figure 4-4. Voltage Measurement

Table 4-1. Voltage Input Divider

FUNCTION	RANGE	INPUT DIVIDER	RANGE OF A/D CONVERTER INPUT
DC VOLTAGE	200 mV	1/1	-200 mV to +200 mV
	2V*	1/1	-2V to +2V
	20V	1/100	-200 mV to +200 mV
	200V	1/1000	-200 mV to +200 mV
	1000V*	1/1000	-2V to +2V (1V max. input)
AC VOLTAGE	200 mV	1/1	0 to -200 mV
	2V	1/10	0 to -200 mV
	20V	1/100	0 to -200 mV
	200V	1/1000	0 to -200 mV
	750V*	1/1000	0 to -2V (-0.75V max. input)
*Integrator gain in a/d converter reduced by factor of 10.			

4-7. Current Measurement

Current measurements are made using a double-fuse-protected, switchable, five-terminal current shunt (0.1 ohm, 1 ohm, 10 ohm, 100 ohm or 1 kilohm) to perform the current-to-voltage conversion required by the a d converter. A block diagram of current measurements is shown in Figure 4-5. When the dc current function is selected, the dc voltage drop across the shunt is filtered and applied to the input of the a d converter. When the ac current function is selected the ac voltage drop across the shunt is ac-coupled to the input of the true rms ac converter. The dc representation of the ac voltage is filtered and applied to the input of the a d converter. All current ranges use the ±200 mV a d converter input range.

4-8. Resistance Measurement

Resistance measurements are made using a ratio technique as shown in Figure 4-6. When the resistance function is selected, a series circuit is formed by the ohms source, a reference resistor from the voltage divider (selected by the range switches), and the external unknown resistor. The ratio of the two resistors is equal to the ratio of the voltage drop across each of them. Since the voltage drop across the reference resistor and the value of the reference resistor are known, the value of the second resistor can be determined. Input protection during resistance measurements consists of a thermistor and a double-transistor clamp.

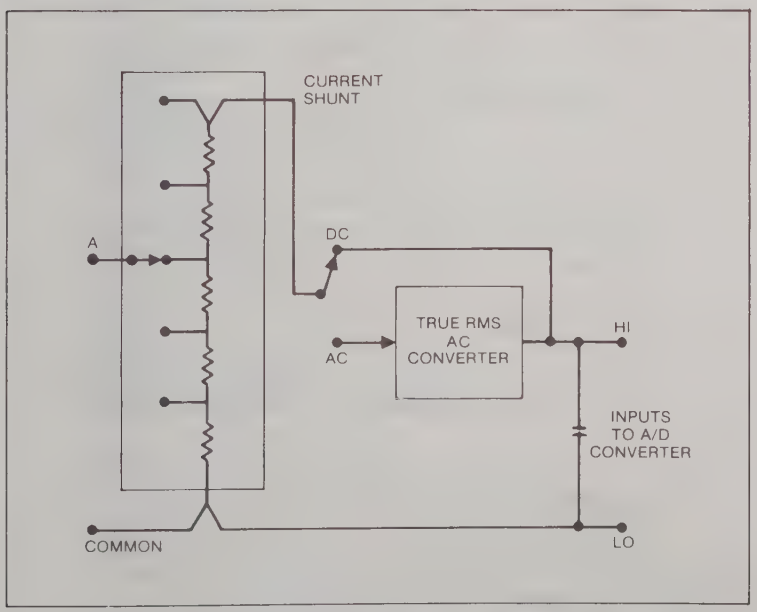


Figure 4-5. Current Measurement

The operation of the a d converter during a resistance measurement is basically as described earlier in this section, with a few exceptions. During the integrate period the voltage drop across the unknown resistor charges the INTEG capacitor. During the read period, the voltage across the known resistor (stored on the flying capacitor) discharges the INTEG capacitor. The length of the read period is a direct indication of the value of the unknown resistor.

4-9. Conductance Measurement

Conductance measurements are made using a ratio technique similar to that used in making resistance measurements as shown in Figure 4-6. The main difference is that the function of the range and unknown resistors in the a d measurement cycle is reversed so that the smaller voltage is applied during the integrate period, which minimizes error due to noise. During the integrate period the voltage drop across the known resistor charges the INTEG capacitor. During the read period the voltage drop across the unknown resistor discharges the capacitor. Consequently the display presents a reading that is the reciprocal of resistance, which is conductance.

4-10. Continuity Measurement

Continuity measurement is a voltage comparison made in the resistance mode as illustrated in Figure 4-6. The 8060A determines whether continuity exists in the

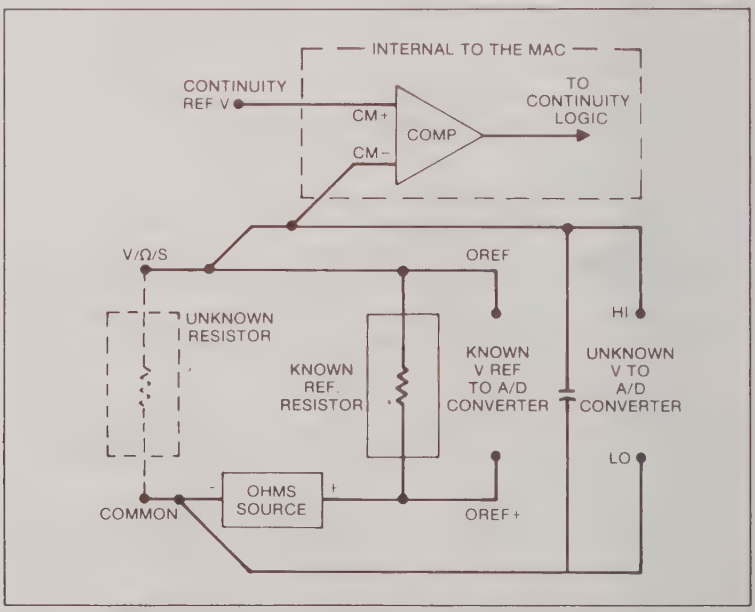


Figure 4-6. Resistance/Conductance/Continuity Measurement

circuit under test by comparing the voltage drop across the external circuit with a continuity reference voltage. If the voltage drop across the external circuit is less than the reference voltage, the comparator sends the appropriate signal to the continuity logic. The continuity logic notifies the microcomputer which turns on the visible indicator (the full-length bar across the top of the display). If the audible indicator is enabled, the continuity logic enables the tone generator.

The detection threshold is typically 10% of the full scale resistance range selected. When the 8060A detects continuity for brief intervals (50 μs or greater), the microcomputer extends the visible and audible indication to a minimum of 200 ms to allow easy perception by the operator.

4-11. Frequency Measurement

Frequency measurement is illustrated in Figure 4-7. The ac input signal is divided by the voltage divider (Figure 4-4) and buffered by the ac rms converter. The signal is then applied to a comparator in the MAC for counting. The counter gate is controlled by the microcomputer, and the range is automatically selected by the software in the microcomputer. For very low frequency input signals, the counter actually measures the period of the input signal which the microcomputer then inverts to derive the corresponding frequency. The display update rate for all ranges is approximately one second (except for frequencies between 12.2 and 16 Hz, which are updated every 1 to 1.3s).

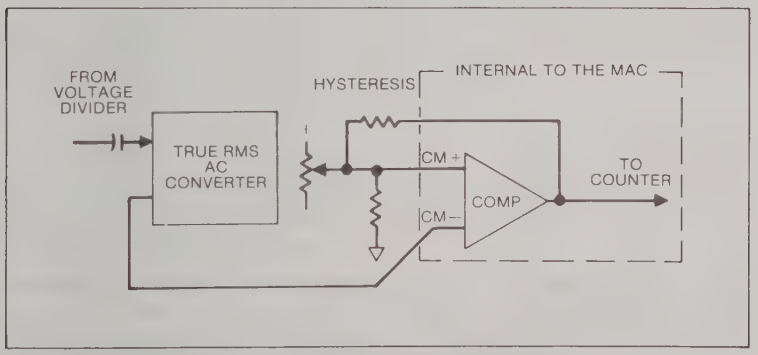


Figure 4-7. Frequency Measurement

Section 5
Maintenance

WARNING

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

5-1. INTRODUCTION

This section of the manual contains information regarding the maintenance of your instrument. It includes information about disassembly, performance tests, calibration adjustments, and troubleshooting. The combined performance tests are recommended as an acceptance test when the instrument is first received, and can be used later as a preventive maintenance tool.

A one-year calibration cycle is recommended to maintain the specifications given in Section 1 of this manual. The test equipment required for the performance tests or calibration adjustments is listed in Table 5-1. Test equipment with equivalent specifications may also be used.

5-2. SERVICE INFORMATION

The 8060A is warranted for a period of one year upon shipment of the instrument to the original purchaser. Conditions of the warranty are given at the front of this manual. Malfunctions that occur within the limits of the warranty will be corrected at no cost to the purchaser. For in-warranty repair, call (toll-free) 800 426-0361 for the address of the nearest Fluke Technical Service Center designated to service your instrument. (In Alaska, Hawaii, Washington, or Canada call 206-356-5400.) Ship the instrument postpaid in the original shipping container (if available). Dated proof-of-purchase may be required for in-warranty repairs.

Fluke Technical Service Centers are also available for calibration and/or repair of instruments that are beyond the warranty period. Call the number listed above for shipping information. Ship the instrument and remittance in accordance with instructions received.

Table 5-1. Required Test Equipment

EQUIPMENT	REQUIRED SPECIFICATIONS	RECOMMENDED TYPE
DMM Calibrator	DC Voltage: 0 to 1000V, ±(0.0075%) AC Voltage: 200 Hz to 1 kHz, 0 to 750V, ±(0.06%) 1 kHz to 10 kHz, 0 to 200V, ±(0.06%) 10 kHz to 30 kHz, 0 to 200V, ±(0.1%) 30 kHz to 50 kHz, 0 to 200V, ±(0.25%) 50 kHz to 100 kHz, 0 to 2.0V, ±(0.75%) Resistance: 100Ω to 10.0 MΩ, ±(0.01%)	John Fluke 5100B with Options Y5000, 5100A-03, and John Fluke 5205A Amplifier
	DC Current: 0 to 2000 mA, ±(0.05%) AC Current: 20 Hz to 3 kHz, 0 to 2000 mA, ±(0.25%)	John Fluke 5100B with Option Y5000 and John Fluke 5220A Amplifier
Reference Resistors	40 MΩ and 290 MΩ, ±(0.1%)	Caddock MG750*
Signal Source	Frequency: 25 mV to 200 mV, 100 Hz to 200 kHz, ±(0.01%)	John Fluke 6010A
DMM	DC Voltage: 200 mV to 20V, ±(0.25%) DC Current: 2 mA to 200 mA, ±(0.25%)	John Fluke 8020A
*Precision high MΩ resistors may be ordered from Caddock Electronics, 3127 Chicago Ave., Riverside, CA, 92507. Be sure to specify 0.1% tolerance.		

5-3. GENERAL INFORMATION

It is recommended that you periodically check the battery and perform the performance tests (paragraphs 5-11 through 5-20).

5-4. Handling Precautions for Using Static Sensitive Devices

CAUTION

This instrument contains CMOS components which can be damaged by static discharge. Static sensitive components on the main pcb include U3 and U4. The microcomputer pcb includes one static sensitive component, U5, the microcomputer. To prevent damage, take the following precautions when troubleshooting and/or repairing the instrument:

- Perform all work at a static-free work station.
- Do not handle components or pcb assemblies by their connectors.

- Wear static ground straps.
- Use conductive foam to store components.
- Remove all plastic, vinyl and styrofoam from the work area.
- Use a grounded, temperature-regulated soldering iron.

5-5. Disassembly and Reassembly

The instrument has two pcbs: the main pcb and the microcomputer pcb. To gain access to the calibration adjustments, the backup fuse, or the LCD, you have to remove only the top cover. You can also do some troubleshooting with only the top cover and the top ac shield off. For other troubleshooting or to gain access to the microcomputer pcb, you have to remove the main pcb from the case. If you remove the main pcb from the case, you will need to perform the calibration adjustments. Be sure to heed the notes and cautions about special handling requirements.

NOTE

It is not necessary to remove the main pcb from the botton case in order to disassemble or reassemble the LCD. However, because the LCD and the microcomputer require similar special handling, the disassembly and reassembly procedures are described together.

CAUTION

To avoid contaminating the pcbs with oil from the fingers, handle the pcbs by the edges or wear gloves. If a pcb does become contaminated, refer to the cleaning information given later in this section.

5-6. CALIBRATION AND BACKUP FUSE ACCESS

Use the following procedure to gain access to the calibration adjustments or the backup fuse (F2):

1. Disconnect the test leads and battery eliminator, if attached. Turn the power switch off.

2. Remove the three phillips screws from the bottom of the case.

3. Turn the instrument face-up and grasp the top cover at both sides of the input connectors. Then pull the top cover from the unit. The backup fuse and the calibration adjustments are now accessible (Figure 5-1).

CAUTION

The function buttons below the display are part of a single elastomeric strip (Figure 5-1) that is held in place by the top cover. When the top cover is removed, the elastomeric strip will be loose and

may be removed. Do not touch or contaminate the carbon-impregnated switch contacts on the bottom of the strip or the switch contacts on the display pcb. If the contacts do become contaminated, clean them with isopropyl alcohol.

4. To reassemble, position the elastomeric strip on the microcomputer pcb so that the small rubber posts on the bottom of the strip are properly seated. Install the top cover and fasten the three screws on the bottom case.

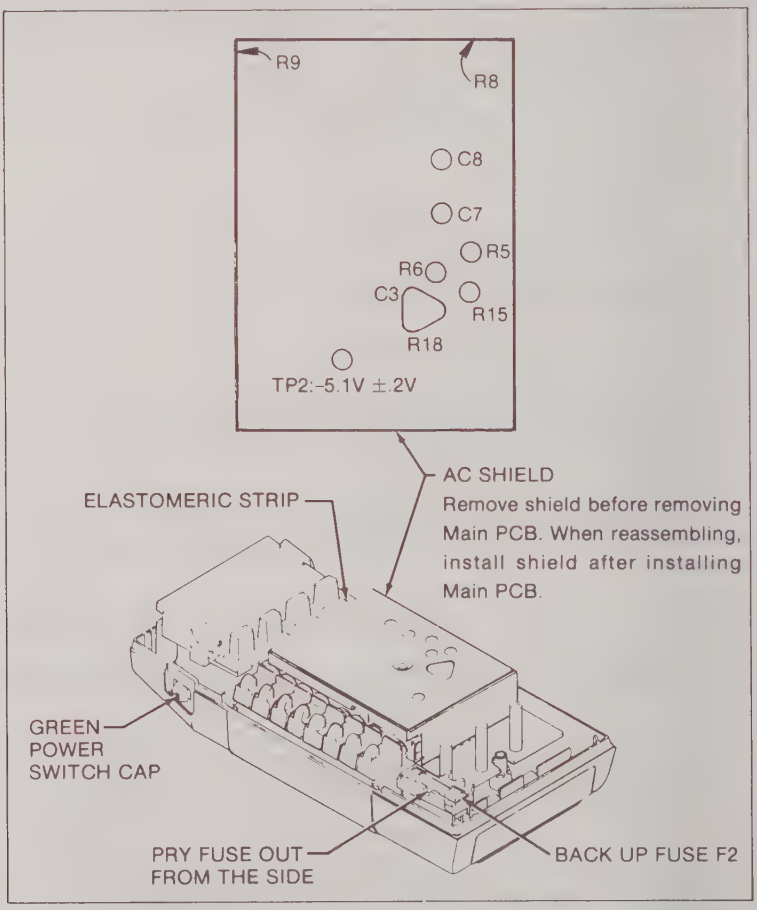


Figure 5-1. Calibration and Backup Fuse (F2) Access

5-7. MAIN PCB ACCESS

Use the following procedure to gain access to the main pcb:

1. Remove the screw in the center of the ac shield and remove the shield.

2. Using your index finger, lift up the lower right corner of the main pcb until it is free. Then pull the pcb to the right until it clears the shelf under the buttons.

CAUTION

Do not touch or contaminate the plastic insulator that is attached to the inside of the case bottom. When the instrument is assembled the insulator makes contact with the leads on the bottom of the main pcb. Contaminants could cause undesirable conduction paths. If the insulator becomes contaminated, clean with isopropyl alcohol.

3. Reassemble in the logical reverse order and heed the following notes:

   a. When reassembling, be sure to put on the ac shield after the main pcb has been placed in the case bottom. The reason for this is that the screw which holds down the ac shield has a spring attached. The spring provides the electrical connection between the top of the ac shield and the bottom of the shield (under the insulator). If the ac shield is attached to the main pcb before the main pcb is in the case, the spring may fold across the insulator and not be in proper position to make the electrical connection.

   b. Be sure to place the green power switch cap over the small black power switch before sliding the main pcb into the case.

   c. Be sure to route the battery-clip wires to the left side of the post under the backup fuse case.

5-8. LCD AND MICROCOMPUTER PCB DISASSEMBLY AND ASSEMBLY

NOTE

This procedure applies to serial number 3995000 and higher.

The procedure for disassembling or assembling the LCD and the microcomputer pcb is not difficult, but the steps must be followed in sequence. Before you try the procedure, examine the components in Figure 5-2 and familiarize yourself with the following handling precautions:

- The microcomputer, U5 (item 4 in Figure 5-2), is a static sensitive CMOS device. Follow standard procedures for handling static sensitive devices.

- The LCD interconnect (item 7) and the microcomputer interconnect (item 5) should not be touched with fingers or contaminated. Handle these items with tweezers and keep them clean.

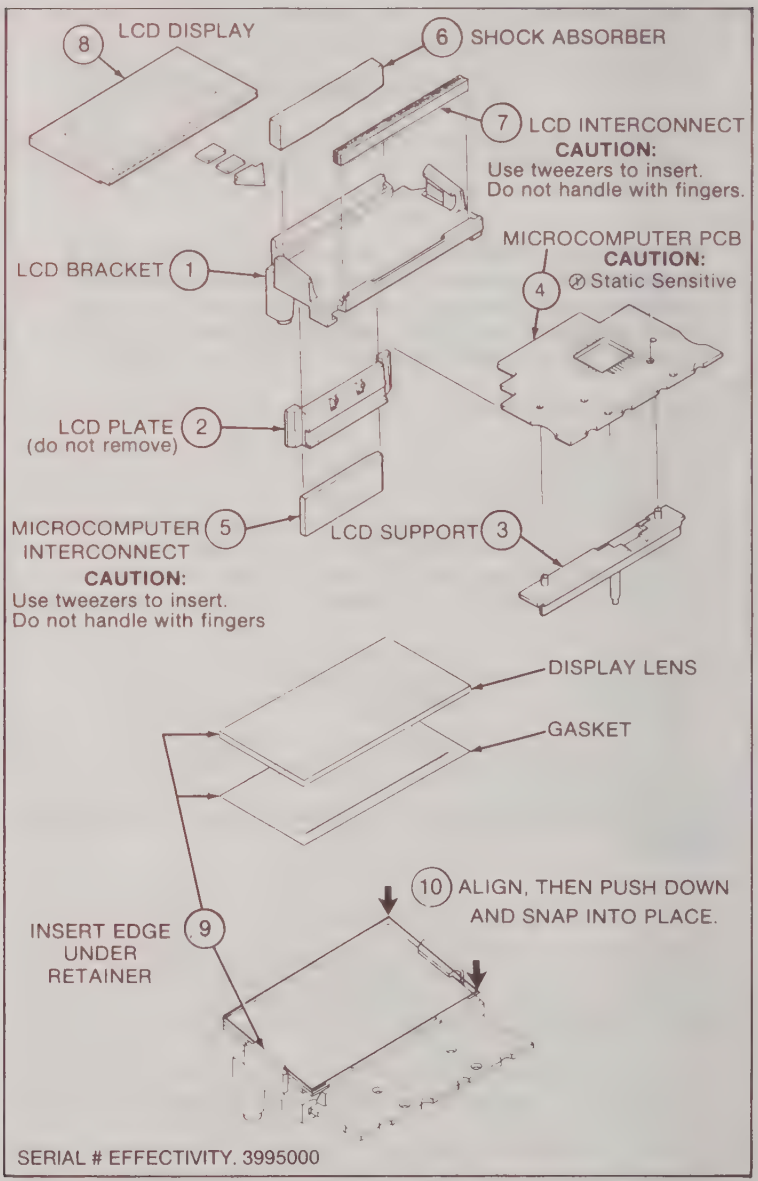


Figure 5-2. Assembling/Disassembling the Microcomputer PCB and LCD

- The microcomputer interconnect (item 5) is susceptible to corrosion caused by the reaction between the metal in the connector and possible contaminates in the air such as smoke or sulfer. Store the connector in an air-tight container if the LCD is disassembled for a long period of time.

- Do not get fingerprints or dirt on the LCD display, the display lens, or the gasket.

- While the LCD and microcomputer pcb are assembled, take care not to press down on the display lens because pressure could damage the LCD.

To disassemble the LCD, use your thumbnails and push on the corners of the LCD display, gasket and display lens so that all three components slide out together as shown in Figure 5-3.

NOTE

It is not necessary to remove the main pcb from the bottom case to disassemble or reassemble the LCD.

To assemble the LCD, use the following procedure:

1. Align the LCD display (item 8) as indicated in Figure 5-2 and slide it into place. The bottom edge of the LCD display should compress the LCD interconnect (item 7) and slide underneath the two plastic notches on the LCD bracket (item 1).

2. Refer to Figure 5-2 and follow steps 9 and 10 to complete assembly.

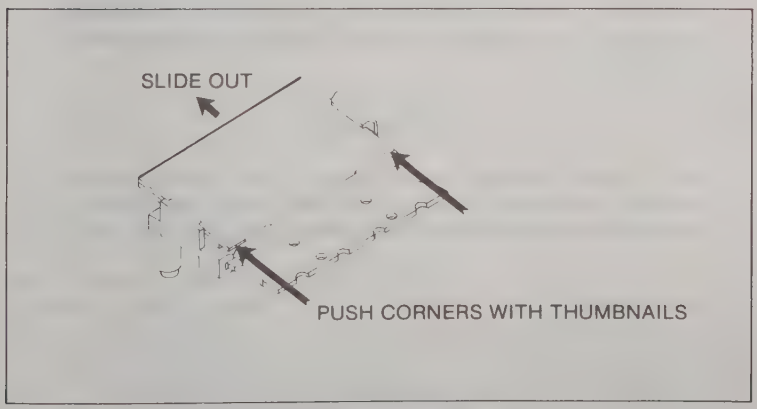


Figure 5-3. Disassembling the LCD

To disassemble the microcomputer pcb, use the following procedure:

1. Turn the main pcb face down and remove the two small screws at the top of the pcb to free the microcomputer pcb.

2. Refer to Figure 5-2. Beginning with item 7, remove items 7 through 3 (leave item 2 attached to item 1). Be sure to observe the handling precautions for items 7, 5, and 4.

To assemble the microcomputer LCD, refer to Figure 5-2. Beginning with item 3, assemble items 3 through 7 (in ascending numerical order). Be sure to follow the handling precautions for items 4, 5, and 7.

5-9. Backup Fuse Replacement

Use the following procedure to replace the backup fuse (F2):

1. Remove the top cover by following the precautions given previously for the calibration and backup fuse access.

2. Use a flat-tipped screwdriver to pry the fuse out of its fuse holder. Pry the fuse from the side as indicated in Figure 5-1.

3. Replace the defective backup fuse with a 3A/600V type BBS-3 (John Fluke 475004). Refer to Section 2-4 for information about replacing fuse F1 (2A/250V; American style: fast acting type AGX2, 1/4 x 1", John Fluke 376582; European style: 5 x 20 mm, John Fluke 460972).

5-10. Cleaning

CAUTION

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. These solutions will react with the plastic materials used in the instrument.

CAUTION

Do not allow the liquid crystal display to come in contact with moisture. Remove the LCD and microcomputer pcb before washing the main pcb and do not install it until the pcb has been fully dried.

Clean the front panel and case with a mild solution of detergent and water. Clean dust from the main pcb with low pressure (<20 psi) dry air. Clean contaminates from the main pcb with isopropyl alcohol and a soft brush, followed by demineralized water and a soft brush (remove the LCD and microcomputer pcb before washing, and avoid getting excessive amounts of water on the switches). Dry with clean, dry air at low pressure, and then bake at 50 to 60°C (124 to 140°F) for 24 hours.

5-11. PERFORMANCE TESTS

The following procedures allow you to compare the performance of your instrument with the specifications listed in Section 1. They are recommended for incoming inspection, periodic calibration, and to verify specifications. If the instrument fails any test, calibration adjustment and/or repair is needed. You do not have to disassemble the instrument to perform the tests. Throughout these procedures, the 8060A being tested is referred to as the UUT (Unit Under Test).

5-12. Initial Procedure

For any of these tests, make sure you do the following:

1. Allow the temperature of the UUT to stabilize in a test environment with an ambient temperature of 23 ±5°C (73 ±9°F) and a relative humidity of less than 80%.

2. Check the fuses and battery and replace them, if necessary.

3. Make sure the leads are disconnected from the UUT. Set the power switch to on and set all other switches to the out (off) position.

5-13. Microcomputer and Display Test

Use the automatic power-on self-test to test the microcomputer and the LCD display. Turn the UUT off, then turn it on while observing the display. All of the LCD segments should turn on. After about one or two seconds, the display should go blank briefly and then respond to switch selections.

5-14. Voltage Test

Use the following procedure to verify proper operation of the dc voltage, ac voltage, and dB functions.

1. Connect the UUT and the DMM Calibrator as shown in Figure 5-4.

2. For each step in Table 5-2, select the UUT function and range as indicated. Program the DMM Calibrator for the specified input signal and verify that the displayed UUT value is within the indicated limits.

5-15. Resistance Test

Use the following procedure to verify proper operation of the resistance function:

1. Connect the UUT and the DMM Calibrator as shown in Figure 5-4.

2. Select the resistance function and follow the steps 1 through 7 as listed in Table 5-3. For each step, select the UUT function and range as indicated. Program the DMM Calibrator for the specified input signal and verify that the displayed UUT value is within the indicated limits.

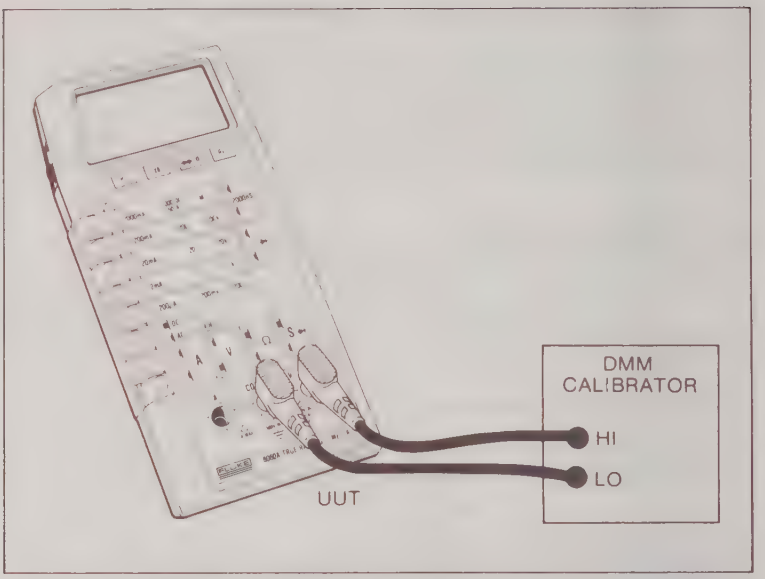


Figure 5-4. General Equipment Connection

NOTE

Most DMM Calibrators do not test resistance values beyond 10 MΩ. To test the resistance function beyond 10 MΩ (optional steps 8 and 9 in Table 5-3), disconnect the DMM Calibrator and connect a precision Reference Resistor for each value.

5-16. Continuity Test

Use the following procedure to verify proper operation of the continuity function:

1. Connect the UUT and the DMM Calibrator as shown in Figure 5-4.

2. Select the resistance function and the 2 kΩ range. Press the ⊷ button once. The ⊷ symbol should appear on the display.

3. Apply a resistance of 100.0Ω. The long bar across the top of the display should appear on the display immediately. A reading of .0997 to .1003 should appear shortly thereafter (negating any test lead resistance).

4. Press the ⊷ button to enable the audible continuity (the 100.0Ω still applied). The symbol should appear on the display with the ⊷ symbol. The tone should sound.

Table 5-2. Voltage Test

STEP	FUNCTION	RANGE	INPUT SIGNAL		DISPLAY LIMITS
			LEVEL	FREQ.	
1		200 mV	+190 00 mV		189.91 to 190.09
2		200 mV	-190 00 mV		-189.91 to -190.09
3		2V	1.9000V	dc	1.8991 to 1.9009
4	DC Voltage	20V	19.000V		18.989 to 19.011
5		200V	190 00V		189.89 to 190.11
6		1000V	1000V		999.3 to 1000.7
7	AC Voltage		100.00 mV rms	50 Hz*	99.70 to 100.30
8	AC Voltage		100.00 mV rms	10 kHz	99.60 to 100.40
9	AC dB	200 mV	2.45 mV rms	1 kHz	-49.0 to -51.0 (dB)
10	AC dB		2.45 mV rms	30 kHz	-47.0 to -53.0(dB)
11	AC dB	2V	1.9000V rms	50 Hz*	7.69 to 7 89 (dB)
12			1.0000V rms	50 Hz*	.9940 to 1.0060
13			1.0000V rms	1 kHz	.9940 to 1.0060
14			1.0000V rms	10 kHz	.9930 to 1.0070
15			1.0000V rms	30 kHz	.9860 to 1.0140
16	AC Voltage	2V	1.0000V rms	100 kHz	.9500 to 1.0500
17			1.0000V rms	20 Hz	.9890 to 1.0110
18			100.0 mV rms	50 Hz*	.0985 to .1015
19			100.0 mV rms	30 kHz	.0950 to .1050
20			100.0 mV rms	100 kHz	.0770 to .1230
21				50 Hz*	9.940 to 10.060
22	AC Voltage	20V	10.000V rms	10 kHz	9.930 to 10.070
23				30 kHz	9.860 to 10.140
24		20V	10.000V rms	100 kHz	9.500 to 10.500
25		200V	100.00V rms	50 Hz*	99.40 to 100.60
26		200V	100.00V rms	10 kHz	99.30 to 100.70
27	AC Voltage	200V	100.00V rms	30 kHz	98 60 to 101.40
28		200V	100.00V rms	100 kHz	95.00 to 105.00
29		750V	750.0V rms	100 Hz	741.5 to 758.5
30		750V	750.0V rms	1 kHz	741.5 to 758.5

*If power line frequency is 50 Hz, use 60 Hz test frequency

Table 5-3. Resistance Test

STEP	RANGE	INPUT RESISTANCE	DISPLAY LIMITS
1	200Ω	short circuit	0.00 to 0.04
2	200Ω	100.00Ω	99.89 to 100.11
3	2 kΩ	1.0000 kΩ	.9991 to 1.0009
4	20 kΩ	10.000 kΩ	9.991 to 10.009
5	200 kΩ	100.00 kΩ	99.91 to 100.09
6	MΩ	1.0000 MΩ	.9983 to 1.0017
7	MΩ	10.00 MΩ	9.95 to 10.05
8 (optional)	MΩ	40.0 MΩ	39.3 to 40.7
9 (optional)	MΩ	290 MΩ	282 to 298

5. Remove the connections to the input of the UUT. The tone should stop and the bar should disappear from the display. The display should indicate OL (overrange) along with the ⊶⊷ and ⊣⊢ symbols.

5-17. Conductance Test

Use the following procedure to verify proper operation of the conductance function:

1. Connect the UUT and the DMM Calibrator as shown in Figure 5-4.

2. Select the conductance (S) function.

3. Apply a resistance of 1.000 MΩ. A reading of 993.0 to 1007.0 should appear on the display.

4. Remove the resistance from the inputs to the UUT. The display should read 0.0 to 0.2.

5-18. Current Test

Use the following procedures to verify proper operation of the dc and ac current functions:

1. Connect the UUT and the DMM Calibrator as shown in Figure 5-5.

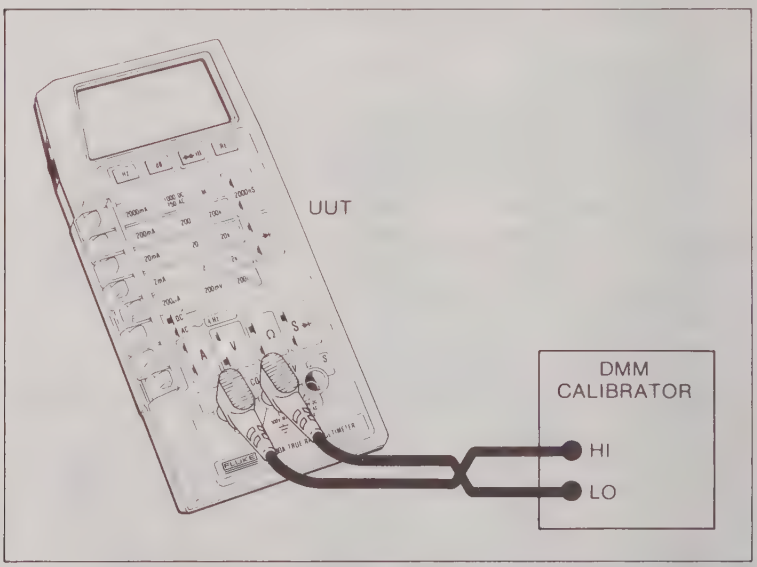


Figure 5-5. Equipment Connection for Current Test

2. For each step in Table 5-4, select the UUT function and range as indicated. Program the DMM Calibrator for the specified input signal and verify that the displayed UUT value is within the indicated limits.

5-19. Diode Test

Use the following precautions to verify proper operation of the diode test:

1. Remove any connections to the inputs of the UUT and select the diode test function. The display should indicate OL (overrange).

2. Connect the UUT and the DMM Calibrator as shown in Figure 5-4 and apply a resistance of 1.000 kΩ. A reading of .9000 to 1.1000 should appear on the UUT display.

3. Using a DMM, measure the output current. The current should be approximately 1 mA ±10%

5-20. Frequency Test

To verify the proper operation of the frequency function, connect the signal source to the V and COMMON inputs of the UUT. Select ac voltage and push the Hz button to select the frequency function. Follow the steps listed in Table 5-5.

Table 5-4. Current Test

STEP	FUNCTION	RANGE	INPUT SIGNAL		DISPLAY LIMITS
			LEVEL	FREQ.	
1		200 μA	190.00 μA		189.60 to 190.40
2		200 μA	-190.00 μA		-189.60 to -190.40
3		2 mA	1.9000 mA		1.8960 to 1.9040
4	Current dc	20 mA	19.000 mA	dc	18.941 to 19.059
5		200 mA	190.00 mA		189.41 to 190.59
6		2000 mA	1900.0 mA		1894.1 to 1905.9
7		2000 mA	-1900.0 mA		-1894.1 to -1905.9
8	Current ac	20 mA rms	19.000 mA	1 kHz	18.848 to 19.152

Table 5-5. Frequency Test

AC VOLTS RANGE	INPUT SIGNAL		DISPLAY LIMITS
	LEVEL	FREQ.	
200 mV	20.0 mV	100.00 Hz	99.94 to 100.06 ±3 counts*
200 mV	100.0 mV	190.00 Hz	189.91 to 190.09
2V	200.0 mV	19.000 kHz	18.991 to 19.009
*May be noisy due to low signal level.			

5-21. CALIBRATION ADJUSTMENTS

Under normal operating conditions the 8060A should maintain the specifications given in Section 1 of this manual for at least one year after calibration. If your 8060A has been repaired or if it has failed any of the performance tests, you need to perform the calibration adjustments.

Test equipment needed for the adjustments is listed in Table 5-1. If the test equipment is not available, your nearest John Fluke Service Center will be glad to help. Call the number listed in Section 5-2 of this manual for assistance. After you have completed the calibration adjustments, we recommend that you complete the performance tests to verify proper operation. In the following procedure, the 8060A that is being adjusted is referred to as the UUT (Unit Under Test).

NOTE

The top ac shield should remain installed on the instrument while the calibration adjustments are being performed. The positions of the trimpots and trimcaps are marked on the top ac shield along with a table summarizing the calibration procedures.

NOTE

The performance of the 8060A ac functions is affected by the capacitance between the main pcb and the bottom ac shield, which is dependent on the distance between them. The distance may vary, depending on whether the top cover is installed. To minimize performance variations, press down on the ac shield to simulate top cover installation while you perform the calibration adjustments. After you have performed the adjustments and installed the top cover, if you find that the measurement values obtained for the ac function performance tests are consistently too high or too low, remove the top cover and repeat the adjustments accordingly.

1. Allow the UUT to stabilize with the power off for at least 30 minutes at an ambient temperature of 21 to 25°C (70 to 77°F).

2. Complete the calibration access procedure presented earlier in this section.

3. Connect the equipment as shown in Figure 5-4 and turn on the equipment.

4. On the UUT, select the dc voltage function and the 2 volt range. Turn R6 fully clockwise (CW), and turn R5 fully counterclockwise (CCW).

5. Program the DMM Calibrator for an input of 1.9000V dc. Adjust R5 for a display reading slightly greater than 1.9000. Adjust R6 for a display reading between 1.8999 and 1.9001.

6. On the UUT, select the 200 mV range (dc voltage function).

7. Program the DMM Calibrator for an input of 190.00 mV dc. Adjust R8 for a display reading between 189.99 and 190.01.

8. On the UUT, select the ac voltage function and the 200 mV range. Turn R18 fully CW, and turn R15 fully CCW.

9. Program the DMM Calibrator for an input of 100.00 mV ac at 200 Hz. Adjust R15 for a display reading slightly greater than 100.00. Adjust R18 for a display reading between 99.95 and 100.05.

10. On the UUT, select the 200V range (ac voltage function). Program the DMM Calibrator for an input of 100.00V ac at 10 kHz. Adjust C3 until the display reading is between 99.95 and 100.05.

11. On the UUT, select the 2V range (ac voltage function). Program the DMM Calibrator for an input of 1.0000V ac at 10 kHz. Adjust C7 until the display reading is between .9985 and 1.0015.

12. Repeat steps 10 and 11 before proceeding to step 13.

13. On the UUT, select the 20V range (ac voltage function). Program the DMM Calibrator for an input of 10.000V ac at 10 kHz. Adjust C8 until the display reading is between 9.990 and 10.010.

14. On the UUT, select the 200 mV range (ac voltage function) and press the Hz button under the display. The Hz indicator should appear on the display.

15. Program the DMM Calibrator for an input of 50 mV ac at 100 kHz. Adjust R9 for a stable reading between 99.95 and 100.05.

16. Decrease the signal input by 5 mV and repeat step 15. If the signal level is no longer sufficient to obtain the required reading, leave R9 at the most stable and accurate setting.

5-22. TROUBLESHOOTING

CAUTION

Static discharge can damage MOS components U3, U4, and U5. Follow the handling precautions for static sensitive devices previously described in this section. Never remove, install or otherwise connect or disconnect components without first setting the instrument power switch off and disconnecting any inputs to the instrument.

If necessary, refer to Section 2 for operating instructions or Section 4 for the theory of operation. The troubleshooting information is supported by the schematics and tables in Section 8.

5-23. Self-Tests

The 8060A offers three self-tests: power-on self-test, ratio self-test, and switch decoding self-test. The power-on self-test is automatically performed whenever the instrument is turned on. It is described in Sections 2 and 4. The other two tests function as follows:

5-24. RATIO SELF-TEST

The ratio self-test is an operating mode of the 8060A in which the reference voltage for the a/d converter is applied to the a/d converter during both the integrate and the read periods. If the instrument is functioning properly, the display should read 10000 ±10 counts (the decimal point location depends on the range, and does not affect the number of counts).

To select the ratio self-test, select a voltage or current function. Hold down the ⇠ button while you turn on the instrument. After the power-on self-test has been completed (the display is .8.8.8.8), release the ⇠ button. The instrument should now be in the ratio self-test mode. To cancel the ratio self-test, press the ⇠ button or turn off the instrument.

If the count is within tolerance, it gives a strong indication that the a/d converter is working properly. If the count deviates more than 10 counts from 10000, the probable causes are as follows (in order of probability): a/d converter in U3, leakage around or failure of C16, C18, Z3, R8, or the power supply.

5-25. SWITCH DECODING SELF-TEST

To select the switch decoding self-test, hold down the REL button while you turn on the instrument. After the power-on self-test has been completed (the display is .8.8.8.8), release the REL button. The instrument should now indicate the switch decoding. To cancel the switch decoding self-test, turn off the instrument.

The switch decoding self-test indicates how the software in the microcomputer interprets the configuration of the eight switches and four push buttons. Each function or range that may be selected corresponds to a number that appears in one of the digit positions on the display (see Table 5-6). Notice that if no range is selected, the microcomputer assumes the 200 (μA, mV, Ω) range is selected.

In some cases it may be helpful to know that the microcomputer scans the switches in order from SW5 to SW8 (there is no input for switch SW4, the default range). The microcomputer assumes the first range switch detected as being pushed in is the desired range. For example, if you press in both the 200V and 1000V switches while in dc voltage, the microcomputer assumes you want the 200V range. There are two exceptions: diode test and conductance. If the microcomputer detects that the 2 kΩ switch is selected, it checks for the 20 kΩ switch (indicating diode test selection). If the microcomputer detects the 200 kΩ

Table 5-6. Switch Decoding Self-Test

RANGE	DISPLAY DIGIT 0*
200 (μA, mV or Ω)	0 (default if no range selected)
2	1
20	2
200	3
2000	4
PUSH BUTTON	**DISPLAY DIGIT 1***
none	0
REL	1
⊣⊢)))	2
dB	4
Hz	8
FUNCTION	**DISPLAY DIGIT 3***
AC Voltage	1
DC Voltage	2
AC Current	3
DC Current	4
Resistance	5
Conductance	6
Diode Test	7

*Display digits are numbered 0 through 4 from right (LSD) to left (MSD).

switch is selected, it checks for the MΩ switch (indicating conductance selection).

Also during the switch decoding self-test, the continuity indicator (the long bar across the top of the display) indicates the state of the continuity/frequency comparator. When the voltage at U3-4 (CM) is less than at U3-3 (CM+), the continuity indicator is on. When the voltage at U3-4 is greater than at U3-3, the continuity indicator is off. You can use this feature to check the comparator when troubleshooting the continuity or the frequency functions. R9 controls the setting of the comparator offset.

5-27. Troubleshooting Guide

A troubleshooting guide is presented in Table 5-7. The guide is structured around the performance tests presented earlier in this section. To use this guide, complete the performance tests and note any discrepancies in performance. Then locate the test, symptom, and possible cause of malfunction in Table 5-7. When several possible causes of malfunction are listed, they are listed in order beginning with the most probable to the least probable. A section about troubleshooting the power supply is also included.

The following troubleshooting techniques can be helpful:

- When troubleshooting, remember to use the switch decoding self-test to determine whether the microcomputer properly interprets the function and range selection.

- Do not remove the main pcb from the bottom case unless you must do so to gain electrical access to circuits. You can gain electrical access to almost all of the input circuitry through the switch contact pins on the top of the switch deck (refer to the schematic in Section 8).

- One way to check the input circuitry is to attach a high impedance (>1000 MΩ) DMM at the input of the 8060A a/d converter, U3-6.

- You can do a lot of troubleshooting without the LCD and microcomputer pcb installed. Although there will be no display and the a/d converter and frequency counter will not work, the power supplies still work so you can check the input circuitry, the diode test and ohms sources, and the ac converter. Another advantage is that you gain access to all the pins on U3 without having to turn the main pcb over.

- You can troubleshoot the input circuitry with U3 removed (be sure to disconnect the battery before removing U3). Since U3 controls the power supply, removing U3 will cause the ac converter and diode test source to stop working. However, it will also eliminate any power supply leakages that might be affecting the input circuitry. Since the input protection, input divider and ohms reference resistors, amps protection, current shunts, and a/d input circuits consist of passive components (refer to the schematic in Section 8) you can check them without having U3installed.

Table 5-7. Troubleshooting Guide

TEST AND SYMPTOM	POSSIBLE CAUSE/SUGGESTIONS
POWER ON/ MICROCOMPUTER AND DISPLAY TEST	
No display	Dead battery, battery connections, J4, power supply circuitry.
Missing LCD segments	Display interconnect.
All LCD segments stay on	Microcomputer connector, U5, U3, pcb lands open, C15 shorted.
Entire display is dim	Low battery, power supply low, display interconnect.
Some display segments are dim or ghosting	Display interconnect, contamination on pcb connector or LCD.

Table 5-7. Troubleshooting Guide (cont.)

TEST AND SYMPTOM	POSSIBLE CAUSE/SUGGESTIONS
POWER SUPPLY	
VDD (voltage between TP7 and common) ≠5.2 ± 0.12V	U3, Q1, VR1
VDG (voltage between TP7 and TP8) ≠3.15 ± 0.08V	U3, C12, U5
VSS (voltage between TP2 and common) ≠ -5.1 ± 0.27V	U4, C21, C23
TP4 ≠1.225 ±0.025V	
U3-11 ≠1.0000 ± 0.0004V	
	Hint: If you suspect U3 power supplies are bad, you can drive the 8060A power supplies externally. Remove battery, μC pcb, and U3. Apply +5.2V at TP1—you can then check the ac converter, diode test source, VR2, U4, and the power supply circuitry.
VOLTAGE TEST - DC	
Gross error (constant reading of 0.00 or OL)	Perform ratio self-test in dc volts. If count is good, U3 is good. If count is way off, suspect U3, C9, R33, R8, Z3, C16 or C18.
Ratio self-test passes, but constant reading of 0.00	R1, R2 (fusible resistors—replace with exact equivalent only), RJ1, RJ2, RJ3, RJ4 (varistors turn yellow when shorted), open circuit in front end, bad component in input divider, U3 pins 6 and 7 shorted. (Hint: check high impedance dc voltage first, which bypasses the input divider.) Refer to Table 4-1 for input divide ratios.
High impedance dc readings 0.00, normal dc readings correct	R1
DC readings incorrect for all ranges	Leakage from pcb, U3-6/7, contamination
DC readings correct for 200 mV, 2V—incorrect for 20V, 200V, 1000V	Input divider or input divider switches, R2

Table 5-7. Troubleshooting Guide (cont.)

TEST AND SYMPTOM	POSSIBLE CAUSE/SUGGESTIONS
VOLTAGE TEST - AC	
DC readings correct, ac readings incorrect	Switches S3D, S3B U2: check ac converter power supplies: (U2-4 = 5.2 ± 0.12V U2-8 = -5.1 ± 0.20V). Apply ac signal to input and use ac voltmeter in 200 mV range to check both sides of R13, U2-5, U2-6.
AC readings too high by factor of 1.1	C24
Too much ripple at S3D wiper	C24, C25
Poor response at high frequencies	C26, R22, S3C, input divider capacitors.
RESISTANCE/CONDUCTANCE TEST	
All ranges incorrect	Ohms source voltage inadequate—using a voltmeter in the 2V or 20V range, measure ohms source voltage between TP11 and common. Refer to Table 5-8 for correct values. Q3, Q4, RT1, R2, R1, Z5 CR1 not supplying enough current (particularly if 200Ω range noisy). Select diode test, connect an external 1 kΩ resistor across the inputs and measure the voltage drop across the resistor - should be approximately 1V (±10%).
CR1 supplying proper current, but readings off	Check values of the reference resistors for the range not working. Check voltage drops across the known and unknown resistors and make sure the ratio works properly.
Low range readings correct, high range readings off	Q3 and Q4 leak- check by seeing if MΩ reads OL with open input, or conductance reads 0 ± 1.0 nS with open input. Main pcb contaminated - clean carefully and check performance.
MΩ range correct, but conductance not working	U3
Conductance reading >1.0 nS with open input	Main pcb contamination, U3 contamination

Table 5-7. Troubleshooting Guide (cont.)

TEST AND SYMPTOM	POSSIBLE CAUSE/SUGGESTIONS
CURRENT TEST	
Constant reading of 0.00	Check fuses F1 and F2 with fuse check procedure in Section 2-4.
Fuses F1 and F2 good, but current readings off	Switches and resistors in current shunt.
High crest-factor ac current readings off	U1
FREQUENCY TEST	
AC volts readings correct, but frequency readings off	Check to see if ac signal at input arrives at U3-4 (inverting input to the frequency comparator in U3). If it is, check frequency calibration. If it is not, check R31, C27, Z7 and S1A.
Frequency calibration is good and signal present at U3-4, but frequency readings off	Frequency comparator in U3 not responding. To check comparator, select switch-decoding self-test and apply input of 15 mV ac in the 200 mV ac range. Adjust R9 so that the continuity bar at the top of the display flashes off and on. If the bar will not flash, U3 is bad. If the bar flashes, but frequency readings are still off, U3 or U5 are bad. Check oscillation of crystal Y1 by measuring the frequency at U3-38 with another frequency counter - should be 40.000 ±0.020 kHz.
CONTINUITY TEST	
No response	Select switch decoding self-test—check for proper function decoding and also confirm that the continuity comparator responds. R31, S1A
No tone	Q6, R4, LS1. Check U3-1 (tone output) with scope for 2.667 kHz signal.
DIODE TEST	
No readings or very low readings	CR1 (diode test source). To check CR1, select diode test, connect an external 1 kΩ resistor across the inputs and measure the voltage across the resistor — should be approximately 1V (±10%).

Table 5-7. Troubleshooting Guide (cont.)

TEST AND SYMPTOM	POSSIBLE CAUSE/SUGGESTIONS
BT INDICATOR BT indicator not displayed when battery voltage is less than 5.6V	U3, Z4—U3 compares voltage at pin 18 (BTI) with voltage at pin 10 (COM—analog common voltage). BT turns on if U3-18 voltage is greater than common, turns off if it is less (±50 mV)

Table 5-8. Troubleshooting the Resistance Function: Voltage Sources for Ranges

RANGE	VOLTAGE SOURCE (±10%)	COMMENT
200Ω 2 kΩ 20 kΩ 200 kΩ MΩ	4.5V 1.2V 1.2V 1.2V 2.1V	These values should be obtained when no external resistors are connected to the resistance inputs. Measure voltage between common (J2) and TP10. Note that the MΩ and 200 kΩ ranges will be loaded by a 10 MΩ input impedance. Use a high impedance voltmeter for the measurement or decrease the voltage source magnitude appropriately. A DMM with a 10 MΩ input impedance will read approximately 1.9V in the MΩ range.

Table 5-9. U3 (MAC) Pin Descriptions

PIN NO.	MNEMONIC	DESCRIPTION
1	TONE	2.667 kHz square wave to tone generator.
2 3 4	CFO CM+ CM-	Output, + input, - input, respectively, of the frequency/continuity function comparator.
5	VSS	-5.1V supply (externally generated).
6	HI	Input to the a/d converter.
7	LO	Sense ground for the a/d converter.
8 9	FC+ FC-	Connections to the "flying capacitor" which stores the reference voltage applied to the a/d converter during the read period. Plus and minus signs indicate polarity of stored voltage.

Table 5-9. U3(MAC) Pin Descriptions (cont)

PIN NO	MNEMONIC	DESCRIPTION
10	COM	Analog common.
11	VREF+	Input for 1V reference voltage for a/d converter and power supply.
12 13	OREF- OREF+	Reference input to a/d converter during autozero period for resistance and conductance functions.
14 15	BFH BFL	Output of the a/d buffer circuit.
16	AZ	Input for AZ capacitor.
17	INT	Input for INTEG capacitor.
18	BTI	Battery test input.
19	VIA	+5.2V supply feedback (nominally 1V)
20	CV	Gate drive for JFET. Series pass element
21	VDD	+5.2V supply.
22	VID	Reference voltage for the U3 and U5 digital power supply.
23	VDG	Output of the U3 and U5 digital power supply.
24 25 26 27	AD0 AD1 AD2 AD3	Four-bit parallel data bus between U3 and U5. During the first part of a data transfer operation they carry the address of the register being read or written to. During the remainder of the operation they carry data.
28	WR/	Register write strobe.
29	ALE/	Address Latch Enable.
30	RD/	Register read strobe.
31 32 33 34 35 36 37	IN10 IN11 IN12 IN13 IN20 IN21 IN22	SW5 SW6 SW7 Inputs to U5 indicating the switch SW8 positions. SW1 SW2 SW3
38	CLKO	40 kHz clock which drives the U5 clock input (crystal frequency divided by 80).
39 40	XTALI XTALO	Connections to the crystal oscillator.

Section 6
List of Replaceable Parts

6-1. INTRODUCTION

This section contains an illustrated parts list for the instrument. Components are listed alphanumerically by assembly. Both electrical and mechanical components are listed by reference designation. Each listed part is shown in an accompanying illustration.

Parts lists include the following information:

1. Reference Designation
2. Description of each part
3. FLUKE Stock Number
4. Federal Supply Code for Manufacturers. (See Code-to-Name list at the end of this section.)
5. Manufacturer's Part Number
6. Total Quantity per assembly or component

6-2. HOW TO OBTAIN PARTS

Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions if necessary.

To ensure prompt and efficient handling of your order, include the following information.

1. Quantity

2. FLUKE Stock Number
3. Description
4. Reference Designation
5. Printed Circuit Board Part Number
6. Instrument Model and Serial Number

CAUTION

Indicated devices are subject to damage by static discharge.

6-3. MANUAL STATUS INFORMATION

The following Manual Status Information table defines assembly revision levels documented in this manual. To identify the configuration of the pcb's used in your instrument, refer to the revision letter (marked in ink) on the component side of the pcb.

Manual Status Information

REF OR OPTION NO.	ASSEMBLY NAME	FLUKE PART NO.	X = The PCA revision levels documented in this manual.																			
			–	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P			
A1	Main PCB Assembly	865803			X																	
A2	Display PCB Assembly	538306				X																

6-4. TECHNICAL SERVICE CENTERS

A list of technical service centers is provided at the end of this manual.

Table 6-1. 8060A Final Assembly
(See Figure 6-1.)

REFERENCE DESIGNATOR -A->-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOT -E-
A 1	*	MAIN PCB ASSEMBLY	642124	89536	865803	1	
A 2	*	DIGITAL PCB ASSEMBLY	612721	89536	538306	1	
BT 1		BATTERY,9V,0-15MA	696534	59717	216	1	
F 1, 1A		FUSE,.25X1.0,2A,250V,FAST	376582	71400	AGX-2	2	
F 2		FUSE,.406,1.375,3A,600V,FAST	475004	71400	BBS-3	1	
H 1, 5		SCREW,THD FORM,PH,P,STL,4-14,.375	448456	COMMERCIAL		2	
H 2, 6, 7		SCREW,THD FORM,PH,P,STL,7-19,.750	447953	COMMERCIAL		3	
H 3		SCREW,FH,P,STL,6-32,.375	837682	COMMERCIAL		1	
H 8		WASHER,COUNTER SUNK,STAINLESS STEEL	614529	COMMERCIAL		1	
MP 1		BAIL MED PEWTER	616961	89536	616961	1	
MP 2		BRACKET,LCD MOUNTING	795112	89536	795112	1	
MP 3, 29, 30		BUTTON,FUNCTION SWITCH-DK PEWTER	606889	89536	606889	3	
MP 4		BUTTON, POWER SWITCH	456491	89536	456491	1	
MP 5, 31- 34		BUTTON,RANGE SWITCH-DK UMBER	606871	89536	606871	5	
MP 6		CASE BOTTOM	652727	89536	652727	1	
MP 7		CASE,TOP (573980)	538884	89536	538884	1	
MP 8		COVER, BATTERY, MED PEWTER	637686	89536	637686	1	
MP 9		DECAL, TOP CASE	535005	89536	535005	1	
MP 10		TOP SHIELD	604801	22670	604801	1	
MP 11		FLANGE, SWITCH	455881	89536	455881	1	
MP 12, 35- 37		FOOT, NON-SKID	604397	21958	604397	4	
MP 13		GASKET, LCD	605170	3M750	605170	1	
MP 14		CONN,ELASTOMERIC,LCD TO PWB,2.153 L	783191	89536	783191	1	
MP 15		INTERCONNECT, PCB	587014	64914	587014	1	
MP 17		LENS	612747	3Z226	612747	1	
MP 19		PLATE, LCD	612762	89536	612762	1	
MP 21		INSULATOR, SHIELD	604777	05839	604777	1	
MP 22		SHIELD, LOWER	587048	0LDG6	587048	1	

Table 6-1. 8060A Final Assembly (cont.)
(See Figure 6-1.)

REFERENCE DESIGNATOR -A->-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOT -E-
MP 23		SHOCK ABSORBER,LCD	605188	2K262	605188	1	
MP 24		SHOCK ABSORBER	428441	25099	428441	1	
MP 25, 26		SPACER, CASE	458588	89536	458588	2	
MP 27		SUPPORT, LCD	612754	89536	612754	1	
MP 28		SUPPORT, TOP SHIELD	612770	89536	612770	1	
MP 39		TEST LEADS	642033	89536	642033	1	
S 10		SWITCH ELASTOMERIC 4 POSITION	587055	89536	587055	1	
TM 1		8060A INSTRUCTION MANUAL	632661	89536	632661	1	
TM 2		8060A OPERATOR GUIDE CARD	632679	89536	632679	1	
U 5	*	IC,CMOS,4 BIT MICORCOMPUTR,8060A-9000	586321	18520	LU-04116A	1	1
U 6		LCD, 4.5 DIGIT, MULTIPLEXED	799973	18520	LF7010G	1	
W 1		GROUND STRIP,BECU,1.980+-.035	817254	34641	1215-17	1	

An * in 'S' column indicates a static-sensitive part.

NOTES:

NOTE 1 = This component is installed on A2 assembly.
NOTE 2 = Recommended Spare Parts Kit part number 645705.

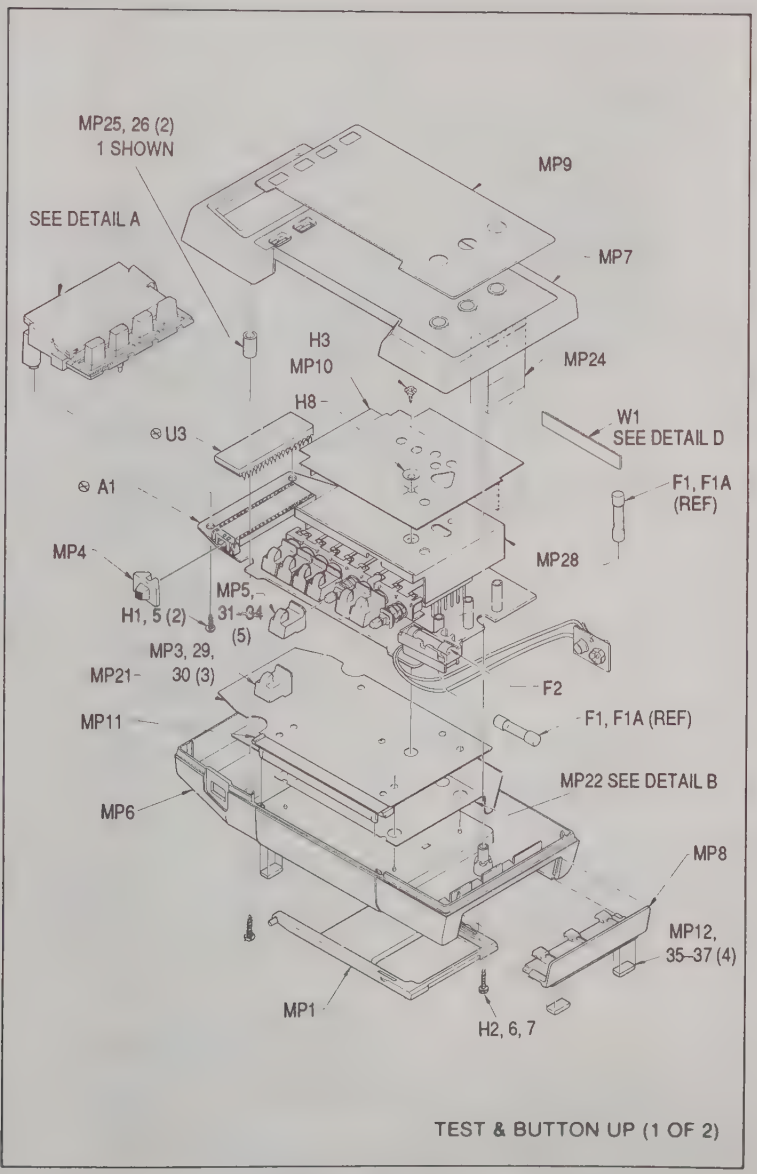


Figure 6-1. 8060A Final Assembly

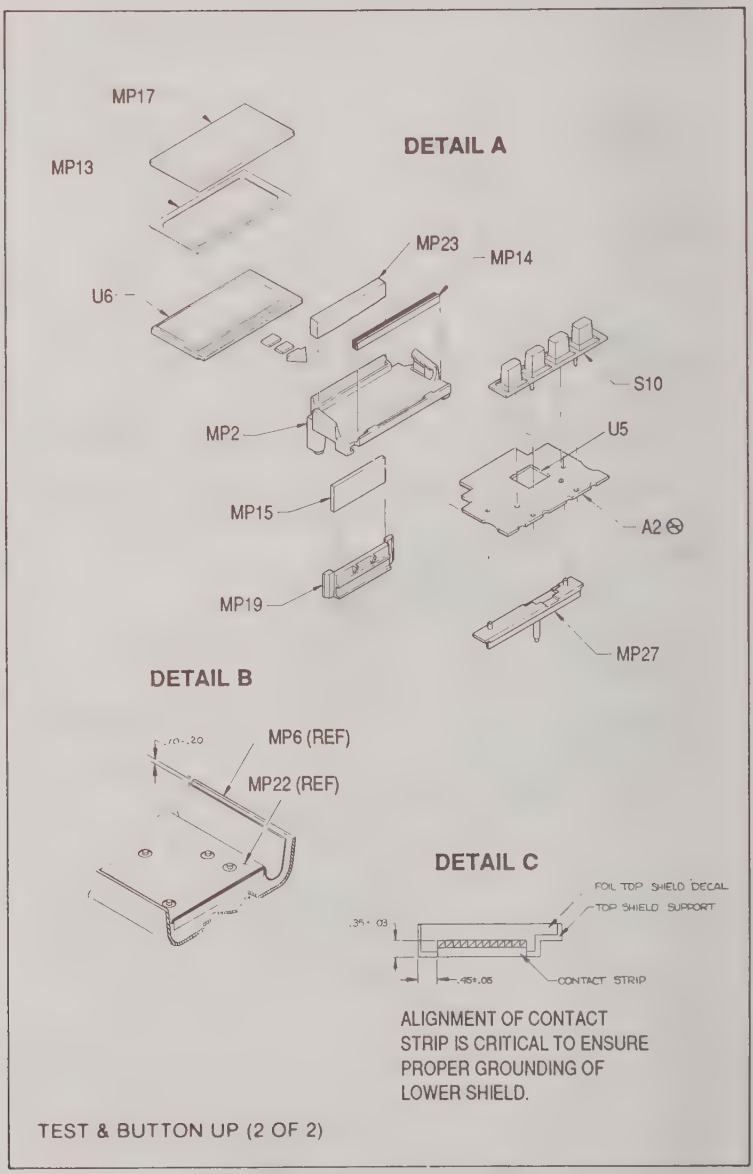


Figure 6-1. 8060A Final Assembly (cont)

Table 6-2. A1 Main PCB Assembly
(See Figure 6-2.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOT -E-
C 1, 23, 24,		CAP,AL,100UF,+-20%,6.3V,SOLV PROOF	615906	62643	SRAC6VB101M6X7C3	5	
C 32, 34			615906				
C 2		CAP,CER,8PF,+-0.25PF,1000V,C0H	643551	51406	DD05851NP08R0C1KV	1	
C 3		CAP,VAR,0.25-1.5PF,1700V,TEFLON	218206	52769	ER-530-000	1	
C 4		CAP,CER,47PF,+-2%,100V,C0G	832295	04222	SR591A470GAATR1A	1	
C 5		CAP,CER,0.01UF,+-2%,50V,C0G	631044	04222	SR305A103GAATR1A	1	
C 6		CAP,CER,820PF,+-2%,50V,C0G	631002	04222	SR595A821GAATR1A	1	
C 7		CAP,VAR,4.2-20PF,100V,CER	631408	52769	GKG20051	1	
C 8		CAP,VAR,9-90PF,50V,CER	643130	51406	TZ03R900FR174	1	
C 9, 18		CAP,POLYPR,0.22UF,+-10%,160V	446799	37942	171/0.22/K/160/F	2	
C 10, 14		CAP,CER,0.01UF,+-20%,50V,Z5U	659045	04222	SR595E103MAA	2	
C 11, 15, 33,		CAP,CER,0.22UF,+-20%,50V,Z5U	831982	04222	SR295E224MAATR1A	4	
C 35			831982				
C 12, 21		CAP,AL,10UF,+-20%,16V,SOLV PROOF	602326	62643	SRAC16VB10RM4X7C3	2	
C 13, 27, 30,		CAP,CER,0.01UF,+-20%,50V,X7R	816249	04222	SR075C103MAATR1A	5	
C 31, 37			816249				
C 16		CAP,TA,1UF,+-10%,35V	161919	56289	199D105X0035AA2	1	
C 17		CAP,POLYES,0.022UF,+-10%,1000V	448183	60935	160/.022/K/1000/H	1	
C 19		CAP,AL,47UF,+-20%,10V	613984	62643	LL10VB47RM6X11C3	1	
C 22		CAP,POLYPR,0.1UF,+-10%,160V	446781	60935	171/0.1/K/160/D	1	
C 25		CAP,TA,5.6UF,+-20%,25V	368969	56289	199D565X0025CA2	1	
C 26		CAP,CER,82PF,+-2%,100V,C0G	512350	04222	SR291A820GAATR1A	1	
C 36		CAP,AL,22UF,+-20%,16V,SOLV PROOF	614750	62643	SRAC16VB22RM5X7C3	1	
C 38		CAP,CER,10PF,+-2%,100V,C0G	512343	51406	RPE110A100G1	1	
CR 1	*	DIODE,SI,N-JFET,CURRENT REG,IF=1.0 MA	334839	17856	J9013	1	
CR 2		DIODE,SI,100 PIV,1.0 AMP	698555	04713	IN4002RL	1	
CR 3, 4	*	DIODE,SI,BV= 75.0V,RADIAL INSERTED	659516	03508	1N4448	2	
J 1- 3		RECEPTACLE	508606	20584	508606	3	
J 4		JACK,PWB,RT ANG	423897	91967	6-205P	1	

Table 6-2. A1 Main PCB Assembly (cont.)

REFERENCE DESIGNATOR -A->-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOT -E-
J 5		CONTACT ASSY TERMINATION	651653	89536	651653	1	
J 6		PIN,SINGLE,PWB,0.025 SQ	603910	QAE89	8-252J70-61	1	
LS 1		AF TRANSD,PIEZO,24 MM	602490	51406	PKM24-4A1	1	
MP 1		FUSE CAP	540716	89536	540716	1	
MP 2		FUSE CLIP	534925	89536	534925	1	
MP 3		FUSE CLIP	535203	1K329	535203	1	
MP 5		SPACER,SWAGED,.250 RND,BR,6-32,.687	544254	9W423	9540B-B-0632	1	
MP 6		SPRING	535211	1K329	535211	1	
Q 1	*	TRANSISTOR,SI,N-JFET,TO-92,RAD T&R	721936	17856	J2660	1	
Q 3, 4, 6	*	TRANSISTOR,SI,NPN,SELECTED IEBO,TO-92	886916	04713	SPS9536	3	
Q 5	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	242065	04713	2N5089	1	
R 1, 2		RES,MF,1K,+-1%,100PPM,FLMPRF,FUSIBLE	474080	91637	CMF65-AR0-1K (T/R)	2	
R 3		RES,CC,100M,+-10%,0.5W	190520	01121	EB1071	1	
R 4		RES,CF,5.6K,+-5%,0.25W	442350	59124	CF1-4 562 J B	1	
R 5		RES,VAR,CERM,2K,+-20%,0.3W	603753	51406	RVS-0707-V-100-3-202M	1	
R 6		RES,VAR,CERM,200,+-20%,0.3W	603738	51406	RVS-0707-V-100-3-201M	1	
R 7		RES,MF,154K,+-1%,0.125W,100PPM	289447	91637	CMF55 1543 F T-1	1	
R 8, 15		RES,VAR,CERM,1K,+-20%,0.3W	614065	51406	RVS-0707-V-100-3-102M	2	
R 9		RES,VAR,CERM,100K,+-5%,0.3W	603761	51406	RVS-0707-V-100-3-104M	1	
R 10		RES,MF,1.62K,+-1%,0.125W,100PPM	772004	59124	MF50DVT1621F REEL	1	
R 11		RES,MF,147K,+-1%,0.125W,100PPM	291344	91637	CMF55 1473 F T-1	1	
R 13, 32		RES,CC,100K,+-5%,1W	641282	01121	GB1045	2	
R 14, 31		RES,CF,22M,+-5%,0.25W	757104	59124	CF1-4 VT 226 J B	2	
R 16		RES,MF,383K,+-1%,0.125W,100PPM	288498	91637	CMF55 3833 F T-1	1	
R 18		RES,VAR,CERM,100,+-20%,0.3W	614057	51406	RVS-0707-V-100-3-101M	1	
R 20		RES,CC,220K,+-10%,1W	109652	01121	GB2241	1	
R 22		RES,CF,240,+-5%,0.25W	830588	59124	CF1-4 VT 241 J B	1	
R 23		RES,CF,4.3,+-5%,0.25W	441550	59124	CF1-4 4R3 J B	1	
R 34, 35		RES,CF,12,+-5%,0.25W	442178	59124	CF1-4 120 J B	2	
R 36		RES,CF,51K,+-5%,0.25W	376434	59124	CF1-4 513 J B	1	
R 37		RES,CF,68K,+-5%,0.25W	376632	59124	CF1-4 683 J B	1	
RJ 1- 4		VARISTOR,430V,+-10%,1.0MA	447672	09214	V430MT7B	4	

Table 6-2. A1 Main PCB Assembly (cont.)

REFERENCE DESIGNATOR -A->-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOT -E-
RT 1		THERMISTOR,RECT.,POS.,1K,+-40%,25C	446849	54583	911P84E102YU13	1	
S 1		SWITCH ASSY	535021	71590	535021	1	
S 9		SWITCH,SLIDE,SPDT	453365	79727	G1-116-0005	1	
U 1		DIODE,SI,RECT,BRIDGE,BV=50V,IO=1A	418582	04713	DF02M	1	
U 2	*	IC, RMS SELECTED	637801	89536	637801	1	
U 3	*	FINAL TESTED PLASTIC PKG-8060 B GRADE	704759	89536	704759	1	
U 4	*	IC,VOLTAGE CONVERTER,10.5 V MAX,8 DIP	586248	34371	ICL7660CPA	1	
VR 1	*	ZENER,UNCOMP,6.2V,5%,20.0MA,0.4W	810283	65940	1N753AT-88	1	
VR 2	*	BANDGAP REF DIODE, 1.22V, 35PPM TC	634154	27014	LM385BX-1.2	1	
VR 3	*	ZENER,UNCOMP,12.0V,10%,10.5MA,0.4W	741074	04713	1N963A	1	
XU 3		SOCKET,IC,40 PIN,DUAL WIPE,RETENTION	756668	00779	2-641616-1	1	
Y 1		CRYSTAL,3.2MHZ,+-0.05%,HC-18/U	513937	89536	513937	1	
Z 1	*	RES NET ASSY TESTED-8060 DIVIDER	539213	89536	539213	1	
Z 2		RES,WW,NET,TOL MATCHED	461491	89536	461491	1	
Z 3	*	DIVIDER RES NET ASSY TESTED - 8060A	611467	89536	611467	1	
Z 4		RES,CERM,NET,TOL/TC MATCHED	614164	91637	CSC09B-00-S3	1	
Z 5		RES,CERM,NET,TOL/TC MATCHED	614149	91637	CSC10B-00-S42	1	
Z 6	*	RES NET ASSY TESTED THICKFILM 8060	737569	89536	737569	1	
Z 7		RES,CERM,NET,TOL/TC MATCHED	615872	91637	CSC10B-00-S41	1	

An * in 'S' column indicates a static-sensitive part.

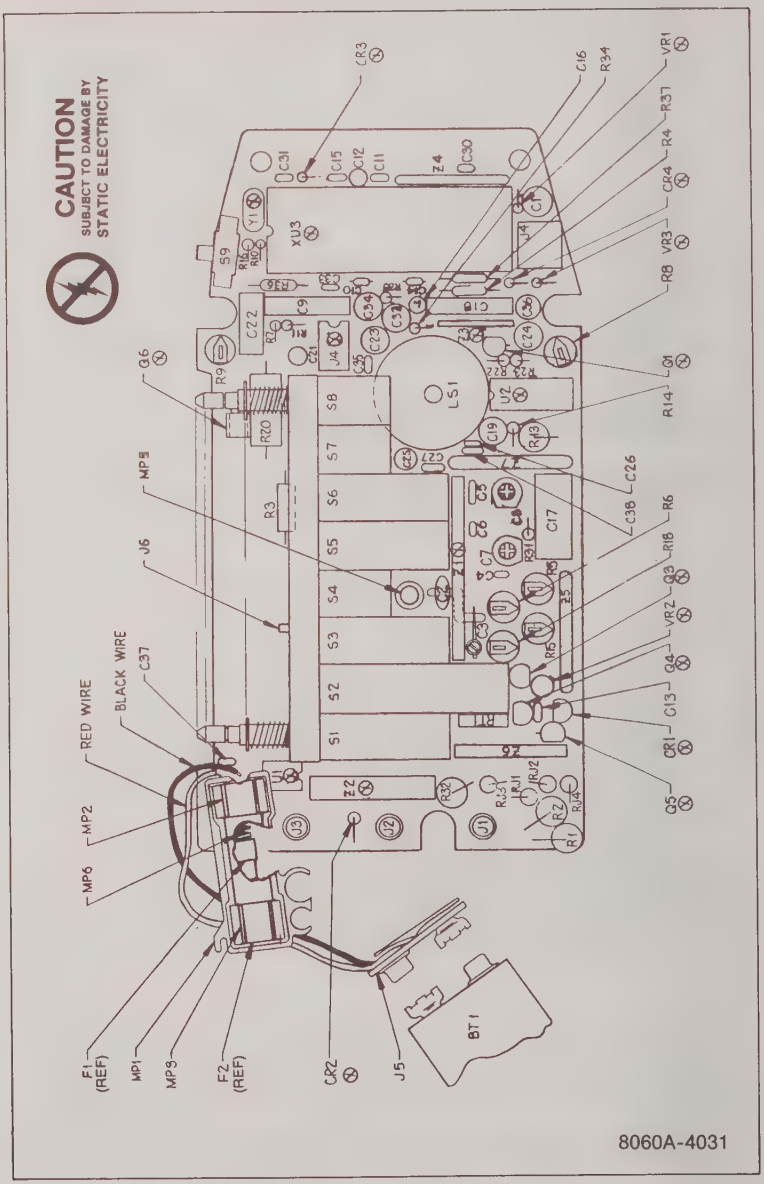


Figure 6-2. A1 Main PCB Assembly

Manufacturer's Federal Supply Code

00779
AMP, Inc.
Harrisburg, PA

01121
Allen Bradley Co.
Milwaukee, WI

03508
General Electric Co.
Semiconductor Products
& Batteries
Auburn, NY

04222
AVX Corp.
AVX Ceramics Div.
Myrtle Beach, SC

04713
Motorola Inc.
Semiconductor Group
Phoenix, AZ

05839
Advance Electrical
Chicago, IL

09214
General Electric Co.
Semiconductor Products Dept.
Auburn, NY

0LDG6
Labels West Inc.
Woodinville, WA

17856
Siliconix Inc.
Santa Clara, CA

18520
Sharp Electronics Corp.
Paramus, NJ

1K329
Pressco Products
Formerly Precision Spring &
Stamping
Kent, WA

20584
Enochs Mfg. Inc.
Indianapolis, IN

21958
Hughes(RS)Co. Inc.
Los Angeles, CA

22670
GM Nameplate
Seattle, WA

25099
General Semiconductor
Industries, Inc.
Tempe, AZ

27014
National Semiconductor Corp.
Santa Clara, CA

2K262
Boyd Corp.
Portland, OR

34371
Harris Corp.
Harris Semiconductor
Products Group
Melbourne, FL

34641
Instrument Specialties
Euless, TX

37942
Mallory Capacitor Corp.
Sub of Emhart Industries
Indianapolis, IN

3M750
Gasket Shop, The
Seattle, WA

3Z226
Foster Grant Corp
Leominster, MA

51406
Murata Erie, No. America Inc.
Symrna, GA

52769
Sprague-Goodman Electronics Inc.
Garden City Park, NY

54583
TDK
Garden City, NY

56289
Sprague Electric Co.
North Adams, MA

59124
KOA-Speer Electronics Inc.
Bradford, PA

59717
Eveready Battery Co. Inc.
St. Louis, MO

60935
Westlake Capacitor Inc.
Tantalum Div.
Greencastle, IN

62643
United Chemicon
Rosemont, IL

64914
Elastomeric Technologies Inc.
Hatboro, PA

65940
Rohm Corp
Irvine, CA

71400
Bussman Div.-Cooper Industries Inc.
St. Louis, MO

71590
CRL Components Inc.
Formerly Mepco/Centralab
A North American Philips Co.
Fort Dodge, IA

79727
C - W Industries
Southampton, PA

89536
John Fluke Mfg. Co., Inc.
Everett, WA

91637
Dale Electronics Inc.
Columbus, NE

91967
National Tel-Tronics
Div. of Electro Audio Dynamics Inc.
Meadville, PA

9W423
Amatom
El Mont, CA

QAE89
Autosplice
Woodside, NY

Section 7
Schematic Diagrams

FIGURE NO.	TITLE	PAGE
7-1.	A1 Main PCB Component Locations	7-2
7-2.	Test Point Locations	7-3
7-3.	A/D Measurement Cycle	7-4
7-4.	Swtich Detail	7-4
7-5.	8060A Schematic Diagram	7-5

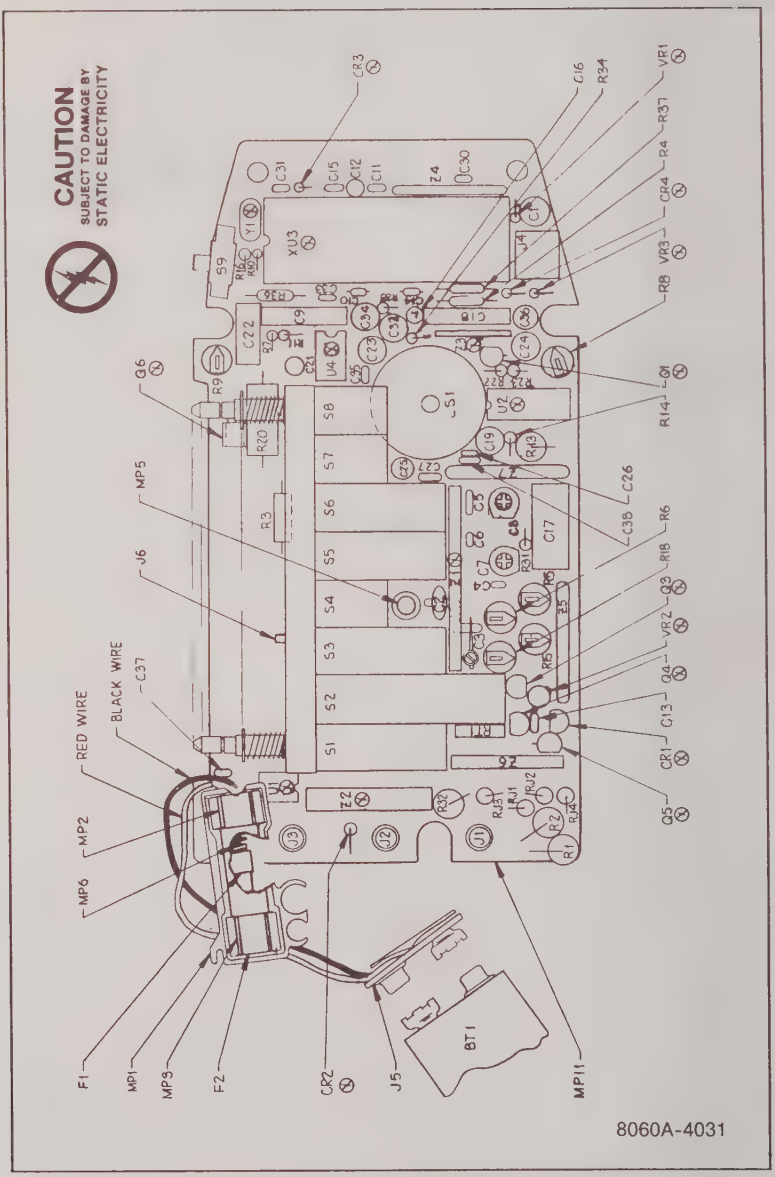
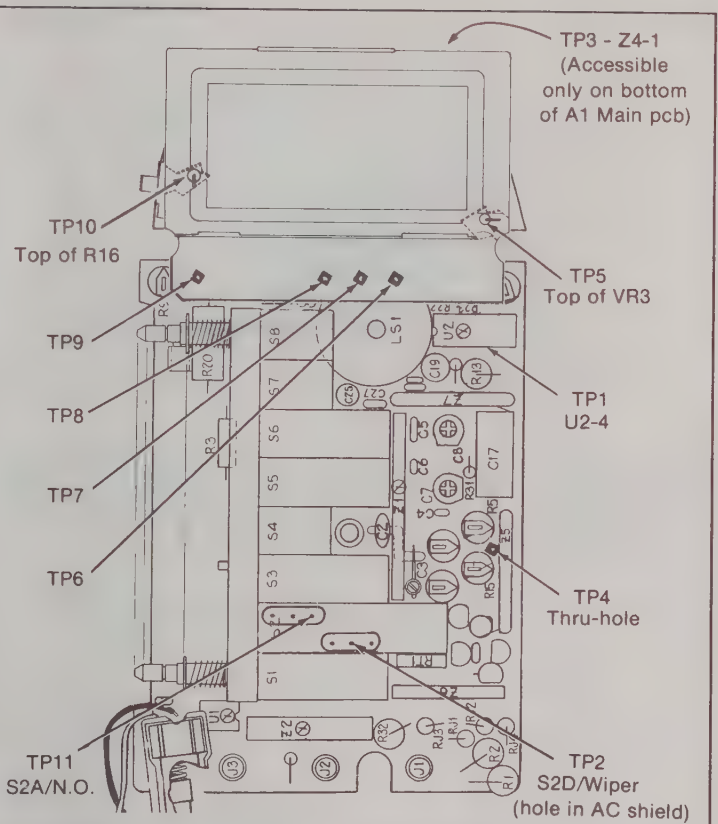
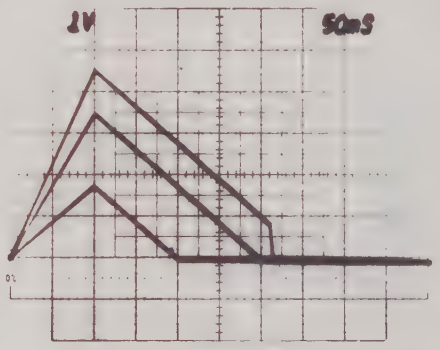


Figure 7-1. A1 Main PCB Component Locations



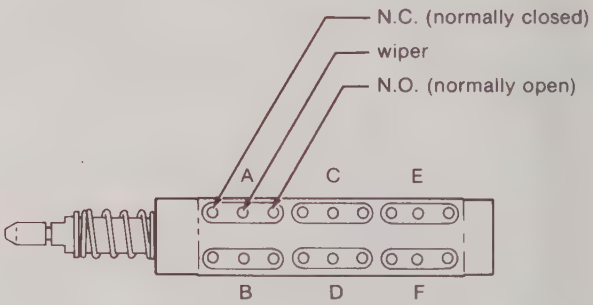
TEST POINT	DESCRIPTION
TP1	VDD, +5.2V supply.
TP2	VSS, -5.1V supply.
TP3	VDG, digital supply, +3.15V ref. to VDD (TP7)
TP4	VBG, bandgap ref., 1.2345V
TP5	Supply ground.
TP6	U5/57, scope trigger, A/D cycle
TP7	VDD, +5.2V supply (on uC pcb)
TP8	VDG, digital supply, +3.15V ref. to VDD (TP7)
TP9	uC clock, 40 kHz nominal
TP10	Freq./Continuity comparator output
TP11	Ohms Source Output

Figure 7-2. Test Point Locations



The photograph shows the a/d measurement cycle for three readings: half-scale, full-scale, and overrange (refer to Figure 4-3 and Section 4 for theory of operation). The three overlaid traces shown were made on a storage oscilloscope connected to U3-17 and triggered by TP6.

Figure 7-3. A/D Mearsurement Cycle



All switches are shown on the schematic in the "out" position.

Figure 7-4. Switch Detail

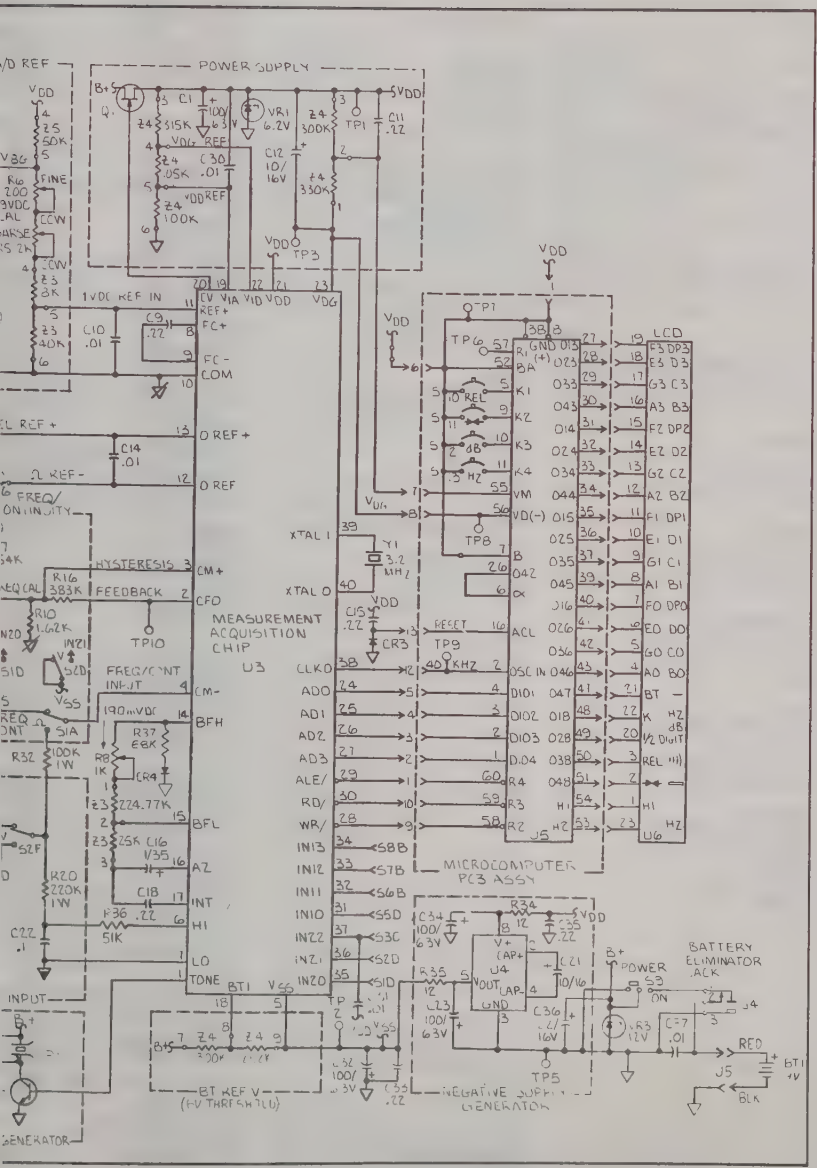


Figure 7-5. 8060A Schematic Diagram

U.S.A

California

Fluke Technical Center
46610 Landing Parkway
Fremont, CA 94538
Tel: (415) 651-5112

Fluke Technical Center
16715 Von Karman Avenue
Suite 110
Irvine, CA 92714
Tel: (714) 863-9031

Colorado
Fluke Technical Center
14180 East Evans Avenue
Aurora, CO 80014
Tel: (303) 695-1171

Florida
Fluke Technical Center
550 S. North Lake Blvd.
Altamonte Springs, FL 32701-5227
Tel: (407) 331-2929

Illinois
Fluke Technical Center
1150 W. Euclid Ave.
Palatine, IL 60067
Tel: (708) 705-0500

Maryland
Fluke Technical Center
5640 Fishers Lane
Rockville, MD 20852
Tel: (301) 770-1576

New Jersey
Fluke Technical Center
East 66 Midland Avenue
Paramus, NJ 07652-0930
Tel: (201) 599-9500

Texas
Fluke Technical Center
2104 Hutton Drive
Suite 112
Carrollton, TX 75006
Tel: (214) 406-1000

Washington
Fluke Technical Center
John Fluke Mfg. Co., Inc.
1420 75th St. S.W.
M/S 6-30
Everett, WA 98203
Tel: (206) 356-5560

INTERNATIONAL

Argentina
Coasin S.A.
Virrey del Pino 4071 DPTO E-65
1430 CAP FED
Buenos Aires
Tel: 54 1 522-5248

Australia
Philips Customer Support
Scientific and Industrial
23 Lakeside Drive
Tally Ho Technology Park
East Burwood
Victoria 3151

Philips Customer Support
Scientific & Industrial
25-27 Paul St. North
North Ryde, N.S.W. 2113
Tel: 61 02 888 8222

Austria
Oesterreichische Philips Industrie
Unternehmensbereich Prof.
Systeme
Triesterstrasse 66
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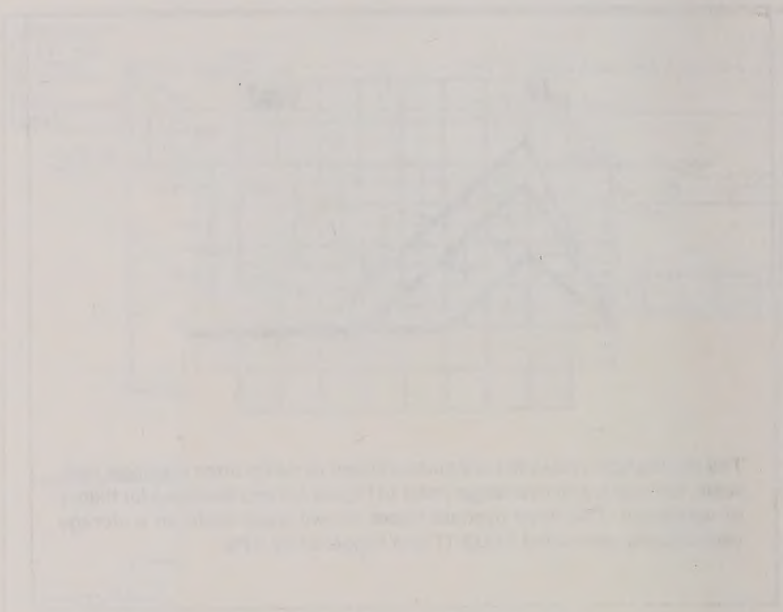

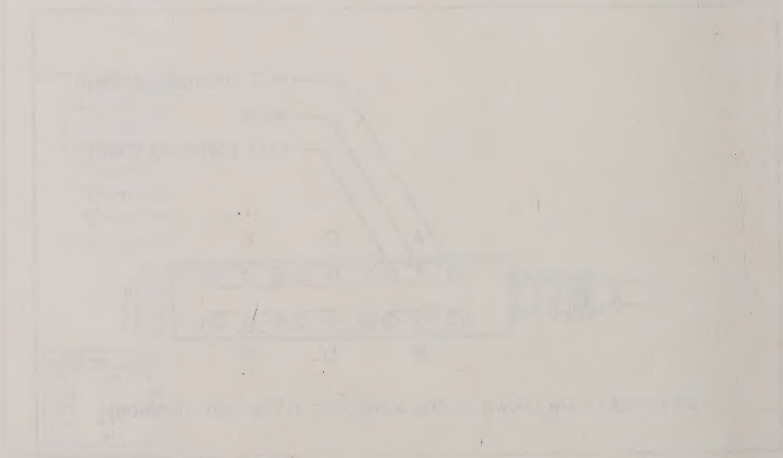

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